



(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:

19.10.2005 Bulletin 2005/42

(21) Application number: **01989927.7**

(22) Date of filing: **05.12.2001**

(51) Int Cl.7: **G06K 9/00**

(86) International application number:
PCT/US2001/046525

(87) International publication number:
WO 2002/047018 (13.06.2002 Gazette 2002/24)

(54) **SWIPED APERTURE CAPACITIVE FINGERPRINT SENSING SYSTEMS AND METHODS**

SYSTEM UND METHODE ZUR KAPAZITIVEN AUFNAHME VON FINGERABDRÜCKEN DURCH
ÜBERSTREICHEN

SYSTEMES DE DETECTION D'EMPREINTE DIGITALE CAPACITIFS A OUVERTURE DE
GLISSEMENT ET PROCEDES ASSOCIES

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE TR**

(30) Priority: **05.12.2000 US 251371 P**

(43) Date of publication of application:
02.01.2004 Bulletin 2004/01

(73) Proprietor: **Validity Sensors Inc.**
Phoenix, AZ 85044 (US)

(72) Inventor: **BENKLEY, Fred, G., III**
Springfield, MA 01118 (US)

(74) Representative: **HOFFMANN EITLE**
Patent- und Rechtsanwälte
Arabellastrasse 4
81925 München (DE)

(56) References cited:

EP-A- 1 018 697	WO-A-98/58342
WO-A-99/28701	WO-A-99/43258
WO-A-02/061668	DE-A- 2 213 813
US-A- 5 076 566	US-A- 5 627 316
US-A- 5 818 956	

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Description

Field of the Invention

[0001] This invention relates to systems and methods for electronically sensing topographic features of an object, such as a fingerprint. More particularly, the invention relates to systems and methods for capacitive sensing of a fingerprint on a swiped finger. For representative disclosures, see WO 99/43258 and WO 99/28701.

Background of the Invention

[0002] Electronic fingerprint sensing has received increased attention as a technique for reliable identification of individuals. Electronic fingerprint sensing may be used in stationary equipment, such as security checkpoints, or in portable devices, such as mobile phones and other wireless devices, and smart cards. Accordingly, electronic fingerprint sensing systems are required to be compact, highly reliable and low in cost.

[0003] Electronic fingerprint sensing using optical methods is well established. A simple lens-based video camera system is disclosed in U.S. Patent No. 4,525,859 issued June 25, 1985 to Bowles et al. More sophisticated units using holographic elements that project a corrected two-dimensional image onto a CCD imaging device are disclosed in U.S. Patent No. 5,109,427 issued April 28, 1992 to Yang.

[0004] More recently, electronic fingerprint sensors incorporating an array of electrodes to create a contour map of finger ridge capacitances have become popular. U.S. Patent No. 4,353,056 issued October 5, 1982 Tsikos discloses a sensor that has a two-dimensional row and column array of capacitors, each including a pair of spaced electrodes with sensing electronics, all overlaid with an insulating film. The sensor relies on the finger ridges to deform a pattern in the insulating film, thereby changing the underlying capacitance detected by the electrode array. This approach, however, requires extraordinary resiliency and durability in the polymer insulating film, which is difficult to achieve.

[0005] A more direct approach is disclosed in U.S. Patent No. 5,325,442 issued June 28, 1994 to Knapp, which discloses a two-dimensional electrode array that forms capacitors between each electrode on the substrate and a grounded finger that is placed in close proximity to the electrode. Thin film transistors located on an insulator are configured as switching elements to scan each row and column in the array. Additional circuitry measures the charging currents for each capacitor on the array as they are scanned, from which the individual capacitances are determined. These values are then used to create a two-dimensional capacitance map of the finger ridge patterns, which closely resembles the physical structure of the finger.

[0006] U.S. Patent No. 6,016,355 issued January 18, 2000 to Dickinson et al also proposes a two-dimensional

matrix of electrodes on a substrate. The electrodes form an array of capacitors to a grounded finger in close proximity. This approach determines the amount of capacitance by placing a fixed voltage on each capacitor in the array and then measuring the time to discharge the capacitor with a constant current source in parallel.

[0007] All of the two-dimensional capacitive array approaches have disadvantages. First is the large number of transistor devices that are required to scan and measure the more than ten thousand capacitors in such an array at a 100 micron pitch. Even if the die area could be reduced by smaller device geometries, a large die size of at least 10mm on a side is required to obtain sufficient contact area. Second is the problem of electrostatic discharge from a charged human body through the finger, breaking down the thin insulator that separates the finger from the sensitive electrodes and destroying the low voltage transistors that operate the array. A third problem is the risk of mechanical damage that is posed by direct physical contact of the finger to an exposed silicon die.

[0008] A fingerprint optical input apparatus including a contact image sensor for viewing a moving finger and providing an image is disclosed in U.S. Patent No. 6,259,108 issued July 10, 2001 to Antonelli et al. A linear sensor imaging method and apparatus for capturing an image of an object which moves, at an unknown variable or constant speed, past one or more linear sensor arrays is disclosed in U.S. Patent No. 6,002,815 issued December 14, 1999 Immega et al.

[0009] All of the known prior art electronic fingerprint sensing systems have had one or more disadvantages, including low reliability and high cost. Accordingly, there is a need for new and improved electronic fingerprint sensing systems and methods.

Summary of the Invention

[0010] With the invention, defined below in claims 1, 20 and 51, conductive elements, or plates, are formed on an insulating substrate to create a one-dimensional capacitive sensing array for detecting topographic variations in an object, such as a finger. The array includes multiple drive plates which are sequentially excited with short duration electronic waveform bursts. An orthogonal pickup plate connected to a charge sensing circuit sequentially detects the intensity of the electric field created by each drive element. With each complete scan of the drive plates, a one-dimensional slice of the relative dielectric constant of the object is acquired. By swiping an object such as a finger across the gap between the drive plates and the pickup plate, and scanning the gap at a much faster rate than the swipe speed, a two-dimensional image based on capacitance is generated. The image closely resembles the object's physical surface features.

[0011] With the invention, image sensing apparatus is provided. The image sensing apparatus comprises at

least one image pickup plate disposed generally laterally with respect to a direction of movement of an object, and a plurality of image drive plates in spaced relation to the image pickup plate to define a plurality of sensor gaps. Features of the object passing over the sensor gaps produce a change in capacitance between respective image drive plates and the image pickup plate.

[0012] In some embodiments, the image pickup plate and the image drive plates are dimensioned and spaced for sensing a fingerprint. In these embodiments, the spacing between each of the image drive plates and the image pickup plate is preferably less than about one-half of the ridge spacing on a typical fingerprint, and the spacing between adjacent image drive plates is preferably less than about one-half of the ridge spacing on a typical fingerprint. In some embodiments, the image drive plates comprise parallel conductors disposed perpendicular to the image pickup plate and spaced from the image pickup plate by respective sensor gaps. In some embodiments, two or more image pickup plates are utilized, and a corresponding number of drive plates are energized simultaneously. Preferably, the image pickup plate and the image drive plates are substantially coplanar. Features of the finger passing above the sensor gaps produce changes in capacitance between respective image drive plates and the image pickup plate.

[0013] The image pickup plate and the image drive plates may comprise conductive traces on a substrate. The substrate may comprise a printed circuit board. In another embodiment, the substrate comprises a flexible substrate. The apparatus may further comprise a substrate support having a contour selected to substantially match the contour of a typical finger. The flexible substrate may be affixed to the contoured substrate support, so that the image sensor matches the shape of the finger.

[0014] The image sensing apparatus may further comprise an excitation circuit for sequentially energizing the image drive plates with image drive signals and a detection circuit for detecting the drive signals capacitively coupled from the image drive plates to the image pickup plate to provide image signals. The image drive signals may comprise sequential signal bursts supplied to respective ones of the image drive plates. The excitation circuit may include circuitry for coupling inactive image drive plates to a reference potential. The detection circuit may comprise a synchronous envelope detector for providing pulses in response to the detected signal bursts. The image sensing apparatus may further comprise an analog-to-digital converter for converting the pulses to digital values, a memory and a processor for storing the digital values in the memory. The processor may initiate a plurality of sequential line scans of the image drive plates to provide a plurality of line scans along lines of the moving object.

[0015] With the invention, rate sensing apparatus is provided. The rate sensing apparatus comprises two or more object detectors spaced apart along a direction of

movement of an object, each of the object detectors including at least one rate drive plate and at least one rate pickup plate. An end of an object passing over each of the object detectors produces a change in capacitance between respective rate drive plates and rate pickup plates.

[0016] Preferably, the rate drive plate and the rate pickup plate of each of the object detectors are disposed generally laterally with respect to the direction of movement of the object. In some embodiments, each of the object detectors includes first and second rate pickup plates disposed on opposite sides of the rate drive plate to form a differential rate sensor.

[0017] The rate drive plates and the rate pickup plates of the object detectors may be dimensioned and spaced for detecting the speed of a moving finger. The rate drive plates and the rate pickup plates may be curved to substantially match the curve of a typical finger end. Preferably, the rate drive plates and the rate pickup plates of the object detectors are substantially coplanar.

[0018] The rate drive plates and the rate pickup plates may comprise conductive traces on a substrate, such as a printed circuit board. In a preferred embodiment, the substrate comprises a flexible substrate that may be contoured to match the contour of a typical finger.

[0019] The rate sensing apparatus may further comprise an excitation circuit for energizing the rate drive plates of the object detectors with rate drive signals and a detection circuit for detecting the drive signals capacitively coupled from the rate drive plate to the rate pickup plate of each of the object detectors to provide rate signals. The rate drive signals may comprise signal bursts. The detection circuit may comprise a synchronous envelope detector. The rate sensing apparatus may further comprise a processing circuit for determining a time delay between the rate signals from the object detectors. The time delay between the rate signals is representative of the speed of the object.

[0020] With the invention, a fingerprint sensing system is provided. The fingerprint sensing system comprises an image sensor including a linear array of capacitive sensors for capacitive sensing of ridge peaks and ridge valleys of a fingerprint on a moving finger, a rate sensor for sensing the speed of the finger as it moves across the image sensor, and a sensor circuit for excitation of the image sensor with image drive signals and for detection of image signals in response to the image drive signals, for excitation of the rate sensor with rate drive signals and for detection of rate signals in response to the rate drive signals, and for coordinating the image signals and the rate signals to provide a fingerprint image.

[0021] The image sensor may comprise at least one image pickup plate disposed generally laterally with respect to a direction of movement of the finger and a plurality of image drive plates in spaced relation to the image pickup to define a plurality of sensor gaps. Ridge peaks and ridge valleys of the fingerprint passing over

the sensor gaps produce changes in capacitance between respective image drive plates and the image pickup plate.

[0022] The rate sensor may comprise two or more finger detectors spaced apart along the direction of movement of the finger. Each of the finger detectors may include at least one rate drive plate and at least one rate pickup plate. An end of the finger passing over each of the finger detectors produces a change in capacitance between respective rate drive plates and rate pickup plates. The sensor circuit may include a processing circuit for detecting a time delay between rate signals from the finger detectors. The time delay between the rate signals is representative of the speed of the finger.

[0023] The image sensor and the rate sensor may be fabricated on a substrate. In some embodiments, the substrate comprises a flexible substrate. In other embodiments, the sensor circuit is fabricated on the substrate with the image sensor and the rate sensor.

[0024] With the invention, a capacitive sensor is provided. The capacitive sensor comprises at least one pickup plate and a plurality of drive plates in spaced relation to the pickup plate. The pickup plate and the plurality of drive plates are substantially coplanar. An object passing above the array of sensor gaps produces a change in capacitance between respective drive plates and the pickup plate.

Brief Description Of The Drawings

[0025] For a better understanding of the invention, reference is made to the accompanying drawings, which are incorporated herein by reference and in which:

Fig. 1A is a block diagram of an image sensing system in accordance with an embodiment of the present invention;

Fig. 1B illustrates an embodiment of the present invention, showing a finger being swiped across a fingerprint image sensor;

Fig. 2A shows a possible electric field distribution when a ridge peak of a fingerprint is being sensed according to an embodiment of the present invention;

Fig. 2B shows the electric field distribution when a ridge valley of the fingerprint is being sensed according to an embodiment of the present invention;

Fig. 3 is a block diagram of an image sensing circuit according to an embodiment of the present invention;

Fig. 4 is a schematic diagram of an embodiment of an image sensor, illustrating parasitic field lines that may be encountered during operation of the present invention;

Fig. 5 illustrates an embodiment of an image sensor wherein the substrate is flexible;

Fig. 6 illustrates an image sensor according to an embodiment of the present invention;

Fig. 7 illustrates an image sensor according to another embodiment of the present invention;

Fig. 8 illustrates an image sensor according to yet another embodiment of the present invention;

Fig. 9 illustrates a rate sensor according to an embodiment of the present invention;

Fig. 10 illustrates a rate sensor according to another embodiment of the present invention;

Fig. 11 illustrates a rate sensor according to yet another embodiment of the present invention;

Fig. 12 shows a rate sensor according to a further embodiment of the present invention;

Fig. 13 shows a rate sensor according to another embodiment of the present invention;

Fig. 14 shows a rate sensor according to yet another embodiment of the present invention;

Fig. 15 is a block diagram of a rate sensing circuit according to an embodiment of the present invention;

Fig. 16 is a block diagram of a rate sensing circuit according to another embodiment of the present invention;

Fig. 17 is a block diagram of a rate sensing circuit according to yet another embodiment of the present invention;

Fig. 18 is a block diagram of a data acquisition and control processor in accordance with an embodiment of the present invention;

Fig. 19 is a flow chart of a rate sensing algorithm according to an embodiment of the present invention;

Fig. 20 is a flow chart of a rate sensing algorithm according to another embodiment of the present invention;

Fig. 21 is a flow chart of a rate sensing algorithm according to yet another embodiment of the present invention;

Fig. 22 is a flow chart of an image line acquisition algorithm according to an embodiment of the present invention;

Fig. 23 is a flow chart of an image acquisition algorithm according to an embodiment of the present invention; and

Fig. 24 is a flow chart of an image acquisition algorithm according to another embodiment of the present invention.

Detailed Description

[0026] Methods and apparatus for detecting topographic variations of an object are described herein. In one aspect of the invention, a sensor having a sensor gap, or sensor aperture, is provided. The object being sensed is swiped over the sensor. As topographic variations in the object pass over the sensor aperture, the capacitance of the aperture changes. The capacitance variations are measured. In some embodiments, the capacitance variations are stored in a computer-readable

medium. The medium can later be read, the changes in capacitance can be interpreted, and an image of the topographic variations in the object can be reconstructed.

[0027] In the practice of swiped aperture sensing, an issue typically encountered is the unknown rate at which the object is swiped. This can produce distorted images. Advantageously, an embodiment of the present invention provides a rate sensor for detecting swipe speed. In embodiments of the present invention, the image is adjusted according to the sensed swipe speed.

[0028] In important embodiments, the object being sensed is a finger, and the topographic variations are ridge peaks and ridge valleys of a fingerprint. In these embodiments, the invention is implemented as a fingerprint sensing system. It should be appreciated that, while the invention is described in terms of fingerprint sensing, the invention may be adapted to detect topographic variations in other objects, and should not be considered as limited in this regard.

[0029] For ease of description, several illustrative examples are described herein in relation to the drawings. These are examples only, and are not intended to be limiting. A person of skill in the art with the benefit of this application may develop variations intended to be within the scope and spirit of this application. Throughout the drawings, like elements are indicated with like reference numerals.

[0030] Fig. 1A shows a fingerprint sensing system 100 in accordance with an embodiment of the present invention. A sensor block 102 receives drive signals from and delivers sensed signals to a sensor circuit 108. Sensor block 102 includes an image sensor 110 and a rate sensor 112. Sensor circuit 108 includes an image sensing circuit 124, a rate sensing circuit 122 and a microprocessor and memory 130. Image sensor 110 receives drive signals 104 from and delivers sensed signals 106 to image sensing circuit 124. Rate sensor 112 receives drive signals 105 from and delivers sensed signals 107 to rate sensing circuit 122. Microprocessor and memory 130 acquires and processes image data and rate data and controls the operation of the system. The components of system 100 are described in detail below.

[0031] Fig. 1B shows the practice of an embodiment of the present invention. In the embodiment shown in Fig. 1B, image sensor 110 includes multiple drive plates 114 and a pickup plate 116. Drive plates 114 are arranged substantially parallel to each other and are connected to sensor circuit 108. Pickup plate 116 is disposed substantially perpendicular to drive plates 114 and is separated from drive plates 114 by a sensor gap 118. More particularly, sensor gap 118 includes multiple sensor gaps between respective drive plates 114 and pickup plate 116. Image sensor 110 thus includes a linear array of sensor gaps.

[0032] Operation of the embodiment of Fig. 1B is now described. In Fig. 1B, a finger 120 is moved, or swiped, perpendicular to sensor gap 118. Sensor circuit 108 se-

quentially energizes drive plates 114 with drive signals. As ridge peaks and ridge valleys of the fingerprint on finger 120 pass over sensor gap 118, the drive signals applied to drive plates 114 are capacitively coupled to pickup plate 116 according to the capacitances of the individual sensor gaps. As described below, the capacitance varies in accordance with the ridge peaks and ridge valleys of the fingerprint passing over the sensor gaps. While a direction of swipe from left to right is indicated in Fig. 1B, it should be appreciated that a direction of swipe from right to left may also be utilized.

[0033] Fig. 2A illustrates the capacitive coupling between drive plate 114 and pickup plate 116 when a ridge peak 202 of finger 120 is within the sensor gap 118. Drive plates 114 and pickup plate 116 are affixed to an insulating substrate 206. Primary electric field lines 204 pass substantially through ridge peak 202 from drive plate 114 to pickup plate 116. Secondary field lines also pass through the body of finger 120. Fig. 2A also shows parasitic field lines that pass through substrate 206 and horizontally across gap 118.

[0034] Fig. 2B illustrates the capacitive coupling between drive plate 114 and pickup plate 116 when a ridge valley 208 of finger 120 is within sensor gap 118. As only the outer field lines of primary electric field lines 204 pass through finger 120 and many primary field lines pass through the air gap, the signal measured in this case is affected by both the bulk capacitance of the finger and the residual parasitic capacitance. The residual parasitic capacitance is the result of substrate field lines 210 passing from drive plate 114 to pickup plate 116 through substrate 206. Advantageously, an embodiment of the present invention may measure the residual parasitic capacitance prior to swiping of finger 120. That measurement is used as a correction to the value measured during fingerprint sensing.

[0035] As further shown in Figs. 2A and 2B, drive plate 114 and pickup plate 116 have a substantially coplanar configuration on substrate 206. A thickness, h , of drive plate 114 and pickup plate 116 is typically very small in comparison with the length of each plate. Furthermore, the spacing between drive plate 114 and pickup plate 116 may be on the order of 25 to 50 micrometers for fingerprint sensing. Thus, drive plate 114 and pickup plate 116 constitute side-by-side coplanar electrodes of a capacitive sensor. The primary field lines 204 in the near field above the sensor gap constitute the primary sensing area. It will be understood that a swiped finger results in fingerprint ridges passing above the sensor gap rather than filling the sensor gap between drive plate 114 and pickup plate 116. Thus, the image sensor 110 advantageously operates as a capacitive sensor having substantially coplanar plates which sense fingerprint ridges and valleys passing above the sensor gap between drive plate 114 and pickup plate 116.

[0036] The image sensor 110 is one embodiment of a capacitive sensor having a pickup plate and a plurality of drive plates which are substantially coplanar. The ca-

capacitive sensor may be used in a variety of sensing applications. In one embodiment, the capacitive sensor is used for position sensing and/or dimension sensing of an object. Thus, an object positioned over the sensor may cover some sensor gaps and not others. As a result, the output signals of the sensor indicate the position and size of the object.

[0037] The dielectric constant of a finger is typically 10-20 times greater than the dielectric constant of the surrounding air. Dielectric constants of finger ridges vary from finger to finger and person to person; hence the wide range of dielectric constants. Since finger 120 has a dielectric constant that differs substantially from the dielectric constant of air, the capacitance between drive plate 114 and pickup plate 116 varies depending on whether a ridge peak or a ridge valley is passing over sensor gap 118. As a result, the drive signal capacitively coupled from drive plate 114 to pickup plate varies in response to the fingerprint features passing over sensor gap 118. These signal variations are used to generate an electronic image of the fingerprint.

[0038] An embodiment of sensor circuit 108 is shown in Fig. 3. In particular, image sensing circuit 124 and microprocessor and memory 130 of Fig. 1A are shown in more detail. A master clock 302 provides a clock signal to mux scanning logic 304 and mixer 306. Master clock 302 can operate over a range of frequencies, for example, 20 MHz-80 MHz, but is not limited to this range. Microprocessor and memory 130 generate control signals for mux scanning logic 304. Outputs of mux scanning logic 304 serve as control inputs to switches 310.

[0039] The clock signal from master clock 302 is gated by switches 310 to provide signal bursts 312. A low impedance buffer 314 activates each drive plate 114 with signal burst 312. The signal bursts 312 are generated by standard circuit elements known to those skilled in the art and are derived from a common frequency reference of master clock 302 signal.

[0040] Mux scanning logic 304 may sequentially activate switches 310 to scan the drive plates 114. In one embodiment, master clock 302 operates at 40 MHz, and each switch 310 is gated on for about 2-5 microseconds. The sequential signal bursts 312 applied to drive plates 114 provide a linear scan of the capacitive sensors between the ends of drive plates 114 and pickup plate 116. Because the scan speed is large in comparison with the finger swipe speed, a line scan of the fingerprint is produced.

[0041] One of skill in the art will appreciate that drive plates 114 need not be driven sequentially. In fact, the drive plates 114 may be driven in any order. Further, drive plates 114 need not be driven with bursts of master clock 302 signal, but may be driven by any periodic signal, such as a sine wave.

[0042] When its control input is activated, switch 310 delivers a gated clock signal from master clock 302 to low impedance buffer 314. Signal burst 312 output by low impedance buffer 314 is capacitively coupled to

pickup plate 116. As discussed above, the capacitive coupling is a function of the fingerprint features passing over the sensor gap 118. When the input to switch 310 is not activated, low impedance buffer 314 drives its connected drive plate 114 to ground. Any parasitic fields between the activated drive plate and the inactive drive plates, consequently, are shorted to ground. By capacitive coupling, pickup plate 116 detects the signal bursts 312 and provides the capacitively coupled signals to a variable gain amplifier 316.

[0043] The gain of variable gain amplifier 316 may be controlled by the output of a digital-to-analog converter 318 connected to microprocessor and memory 130. The gain may be adjusted to provide a desired output level despite variable sensing conditions. The output provided by digital-to-analog converter 318 to variable gain amplifier 316 may result in a gain adjustment based on the impedance of the finger.

[0044] The signal output from variable gain amplifier 316 is supplied to a band pass filter 320. Band pass filter 320 is centered at the frequency of master clock 302 and may have a Q of 10.

[0045] The output of band pass filter 320 is multiplied in a mixer 306 by the clock signal from master clock 302. Mixer 306 performs synchronous envelope detection of signal bursts 312. The output of mixer 306 is a baseband pulse that represents the envelope of the capacitively coupled signal burst. In an alternative embodiment, synchronous rectification may be used for envelope extraction. The amplitude of the pulse output by mixer 306 is a function of the sampled topographic feature of the finger. The pulse amplitude modulated signal is supplied to a low pass filter 322. Low pass filter 322 removes unwanted high frequency harmonics produced by the mixing process. Low pass filter 322 may have group delay characteristics that compensate for phase distortions incurred in the previous signal processing stages. Low pass filter 322 may also be optimized for processing the information coming out of the mixer at the rate at which the drive plates 114 are scanned.

[0046] An analog-to-digital converter 324 converts the output of low pass filter 322 to a digital value. Analog-to-digital converter 324 may have, for example, a resolution of 8-12 bits and is, therefore, capable of resolving the output of low pass filter 322 into, in this example, 256-4096 values. Analog-to-digital converter 324 operates at a sufficient speed (e.g., 200 kilosamples per second) to accommodate the scanning of image sensor 110. Microprocessor and memory 130 receives the output of analog-to-digital converter 324 and stores it in a line buffer described below in connection with Fig. 18. Each stored digital value represents the capacitance between a drive plate 114 and the pickup plate 116 at the time when that drive plate was energized by signal burst 312. The capacitance is modified by the fingerprint feature that passed over the sensor gap at the time when that drive plate was energized. As a result, each stored value represents a fingerprint feature.

[0047] It should be understood that the invention is not limited to the plate driving methodology discussed in connection with Fig. 3. For example, drive plates 114 may be activated in pairs and driven differentially. In this example, at each sampling, one drive plate of the active pair is driven with a signal burst that is out of phase with the signal burst with which the other drive plate 114 of the pair is driven.

[0048] Referring now to Fig. 4, a schematic representation of an embodiment of image sensor 110 is shown. The image sensor shown in the example of Fig. 4 has 11 drive plates. A practical fingerprint sensor has substantially more drive plates as described below. Primary field lines 204 and parasitic field lines 402 are shown for illustrative purposes. Signal burst 312 is shown connected to one of drive plates 114. When each drive plate 114 is driven by signal burst 312, parasitic field lines 402 are generated between the driven plate and its neighbor plates. However, since the inactive plates are connected to ground by low impedance buffers 314, parasitic field lines 402 are shorted to ground. Primary field lines 204, as noted above with respect to Figs. 2A and 2B, are modified by the finger, resulting in detectable changes in the signal capacitively coupled to pickup plate 116.

[0049] Drive plates 114 and pickup plate 116 are formed on substrate 206. Substrate 206 can be any suitable insulating material (e.g., Capton®). In some embodiments, the substrate is flexible so that it conforms to the macro contours of an object being sensed. A flexible substrate may be affixed to a rigid substrate support, as described below in connection with Fig. 5. However, a flat substrate may be used without impairing the capabilities of the sensor. In some embodiments, the substrate 206 may be a rigid or flexible printed circuit board having drive plates 114 and pickup plate 116 formed by conventional etching or deposition processes. These embodiments provide a highly durable fingerprint sensor.

[0050] Drive plates 114 and pickup plate 116 may be formed of any conductive material, such as copper or aluminum. Drive plates 114 and pickup plate 116 may be formed on substrate 206 by any suitable process, including but not limited to etching, deposition and sputtering. Drive plates 114 and pickup plates 116 may be covered with a protective coating such as Capton®.

[0051] The width and spacing of drive plates 114 determines the resolution of the acquired fingerprint image. For example, to achieve an industry standard resolution of 500 dots per inch, the width of each drive plate 114 is approximately 25 micrometers (μm). Similarly, the gaps between adjacent drive plates 114 are 25 μm and the sensor gap 118 is 25 μm to achieve this resolution. This results in a center-to-center spacing of adjacent drive plates 114 of 50 μm .

[0052] Fig. 5 is a cross section of the image sensor on a flexible substrate. Drive plates 114 and pickup plate 116 (not shown in Fig. 5) are formed on a flexible substrate 500. The flexible substrate 500 is affixed to a rigid

substrate support 510 having a contour that matches the contour of a typical finger. It is believed that the curved substrate 500 improves the quality of the fingerprint image.

[0053] As described above, the drive plates 114 and pickup plate 116 of image sensor 110 are substantially coplanar. When drive plates 114 and pickup plate 116 are formed on a flexible substrate, the plates of the image sensor may be deformed from a strictly planar configuration. However in this case, drive plates 114 and pickup plate 116 maintain their side-by-side arrangement and remain substantially coplanar in a local region adjacent to the sensor gaps. That is, any curvature of the flexible substrate is small on the scale of the sensor gaps.

[0054] It should be appreciated that the substrate 206 may be attached to a finger-fitting support (not shown) such that the sensor is permanently contoured to receive a finger. Substrate 206 may also be placed on a tab protruding from the circuit board on which sensor circuit 108 is fabricated, or on any other convenient and ergonomic surface.

[0055] Several embodiments of image sensors in accordance with the present invention are described below. It should be noted that the image sensors are described herein by way of example only, and that the invention is not limited in this respect.

[0056] Fig. 6 shows a top view of one example of a sensor according to an embodiment of the present invention. Drive plates 114 are arranged substantially parallel to each other and substantially orthogonal to pickup plate 116. Drive plates 114 are separated from pickup plate 116 by sensor gap 118, over which the finger is swiped. The length of pickup plate 116 depends on the maximum fingerprint width to be scanned. The lengths of drive plates 114 are selected for convenient connection to the drive circuit.

[0057] Another embodiment of an image sensor according to the present invention is shown in Fig. 7. In Fig. 7, drive plates 114 follow different paths between pickup plate 116 and contacts 702. Contacts 702 provide connections of drive plates 114 to the drive circuit.

[0058] It should be appreciated from Figs. 6 and 7 that drive plates 114 can be any suitable length. Drive plates 114 should preferably have an ergonomically designed length such that the finger being scanned is not impeded by other elements of the system. The image sensor design should permit a smooth and continuous swipe of the finger being scanned.

[0059] In some embodiments, components of sensor circuit 108 may be mounted on the same substrate as the sensors 110 and 112. For example, sensors 110 and 112 may be placed on the opposite side of the substrate from sensor circuit 108. In this example, contacts 702 shown in Fig. 7 provide a connection between the drive circuit and the drive plates 114 through the substrate 206.

[0060] Fig. 8 illustrates yet another embodiment of an

image sensor in accordance with the present invention. The image sensor of Fig. 8 utilizes two pickup plates 116a and 116b in conjunction with substantially U-shaped drive plates 114. In this embodiment, two sensor gaps may be energized simultaneously with a single drive signal, thereby increasing the efficiency of the device. Each pickup plate 116 may require a detection circuit as shown in Fig. 3. However, the number of connections to the drive plates is reduced by one half. It will be understood that a sensor with more than two pickup plates 116 and appropriately configured drive plates 114 may be utilized.

[0061] Embodiments of rate sensor 112 are described below for illustrative purposes only. The invention should not be considered as limited to the embodiments disclosed herein.

[0062] Fig. 9 shows a rate sensor 112 and an image sensor 110 in accordance with an embodiment of the present invention. Image sensor 110 includes drive plates 114 and pickup plate 116 spaced from the ends of drive plates 114 by sensor gap 118, as described above in connection with Figs. 4 and 6. The rate sensor includes two or more spaced-apart object detectors, described herein as finger detectors. Rate sensor 112 includes finger detectors 910, 912, 914 and 916. The finger detectors are spaced apart by a spacing 906 along the direction of finger swipe. The finger detectors 910, 912, 914 and 916 include portions located on opposite sides of image sensor 110 in the embodiment of Fig. 9. Each finger detector includes at least one drive plate and at least one pickup plate, which form a capacitive sensor. Thus, for example, finger detector 910 includes drive plates 910a and pickup plates 910b. The rate drive plates and the rate pickup plates are oriented substantially perpendicular to the direction of finger swipe. In the embodiment of Fig. 9, the rate pickup plates of each finger detector are connected to the pickup plate 116 of image sensor 110. The drive plates of the finger detectors may be activated sequentially by signal bursts, as described above in connection with the image sensor. Rate sensing and image sensing may be performed at different times, such as by time multiplexing, during the fingerprint scanning process.

[0063] The rate sensor 112, rather than sensing fingerprint features, senses the end of the finger as the finger is swiped across image sensor 110. The end of the finger is easier to detect than fingerprint features, because it is a macroscopic feature. In order to sense the bulk of the finger, the gap 920 between the rate plates may be larger than the gap 118 between imaging plates. This allows the electric field lines to penetrate deeper into the finger, reducing the effect of surface features, i.e. fingerprint ridges. Initially, the finger is placed on image sensor 110 and covers all of the finger detectors 910, 912, 914 and 916. As a result, the finger detectors all sense a similar capacitance value. As the finger moves from left to right, the finger end passes finger detector 910 at time t_1 , passes finger detector 912 at

time t_2 , passes finger detector 914 at time t_3 and passes finger detector 916 at time t_4 . Passage of the finger end over each finger detector produces a distinct change in capacitance and a corresponding change in the capacitively coupled drive signal. The changes in capacitively coupled drive signals occur as rate signals at times t_1 , t_2 , t_3 and t_4 for finger detectors 910, 912, 914 and 916, respectively. Since the spacing between the finger detectors is known, the time delay between the rate signals indicative of the finger end is an inverse function of finger speed.

[0064] The finger detectors of the rate sensor 112 are located only on the side of the sensor gap 118 of image sensor 110 from which direction the finger is swiped across the sensor gap. The finger detectors are designed to cover an area of the finger from the furthest ridge desired to be imaged to the end of the finger. The presence or absence of a finger can be detected by measuring the change in the bulk capacitance produced by the finger end as it passes each finger detector. By recording the times of these transitions, such as times t_1 , t_2 , t_3 and t_4 , a time history of finger position can be determined. The time history can be used to compute a finger velocity profile. The granularity of the velocity profile depends on the number of finger detectors and the spacing between finger detectors. Preferably, the spacing between finger detectors is a minimum of the width of three finger ridges, or approximately 0.035 to 0.050 inch.

[0065] A second embodiment of rate sensor 112 is shown in Fig. 10. In this embodiment, the orientation of image sensor 110 is reversed with respect to the direction of finger swipe. Rate sensor 112 is located on the opposite side of image sensor pickup plate 116 from drive plates 114. This configuration permits the rate drive plates and rate pickup plates to extend across the entire width of the sensor, thereby providing larger sensed signals. As shown in Fig. 10, rate sensor 112 includes finger detectors 1010, 1012, 1014 and 1016 spaced apart along the direction of finger swipe by a spacing 1006. Each of the finger detectors includes at least one rate drive plate and one rate pickup plate. Thus, for example, finger detector 1010 includes rate drive plate 1010a and rate pickup plate 1010b. The rate pickup plates of each of the finger detectors 1010, 1012, 1014 and 1016 are connected to the pickup plate 116 of image sensor 110. In other embodiments, the rate pickup plate and the image pickup plate can be electrically isolated and connected to separate sensing circuits.

[0066] A third embodiment of rate sensor 112 is shown in Fig. 11. The embodiment of Fig. 11 uses differential rate sensing. Rate sensor 112 includes finger detectors 1120, 1122, ... 1130 positioned along the direction of finger swipe. Each of the finger detectors has a differential configuration. In particular, each finger detector includes a drive plate and first and second pickup plates located on opposite sides of the drive plate. For example, finger detector 1120 includes a drive plate

1140 and pickup plates 1142 and 1144 located on opposite sides of drive plate 1140. Pickup plate 1142 is spaced from drive plate 1140 by sensor gap 1150, and pickup plate 1144 is spaced from drive plate 1140 by sensor gap 1152. Drive plate 1140 and pickup plates 1142 and 1144 may be elongated conductors oriented perpendicular to the direction of finger swipe across the image sensor 110. In the embodiment of Fig. 11, drive plate 1140 is wider than pickup plates 1142 and 1144 and is connected to a drive circuit via a contact 1146. Preferably, the differential finger detector has a symmetrical configuration, so that the capacitively coupled signals to pickup plates 1142 and 1144 are equal when a finger is not present or when a finger covers both rate sensor gaps 1150 and 1152. The other fingers detector may have a similar construction. In the embodiment of Fig. 11, the first pickup plates of the finger detectors are commonly connected to pickup line 1160, and the second pickup plates of the finger detectors are commonly connected to pickup line 1162.

[0067] As the end of the finger is swiped across the sensor gaps 1150 to 1152, a capacitance versus time profile can be created that has a large peak value due to a capacitance imbalance between pickup plates 1142 and 1144 of finger detector 1120 when the end of the finger has just crossed the first sensor gap 1150 but has not yet crossed the second sensor gap 1152. A differential signal peak is produced sequentially between first sensor gap 1150 and the second sensor gap 1152 as the finger detector 1120 is activated by its associated differential drive plate 1140, while the end of the finger passes. In one embodiment, as soon as the differential signal peak is detected in one finger detector 1120, the next adjacent finger detector 1122 is activated. This sequence continues until a differential signal peak has been detected by the last finger detector 1130.

[0068] Fig. 12 illustrates another embodiment of the differential rate sensor shown in Fig. 11. The differential rate sensor shown in Fig. 12 is similar to the differential rate sensor shown in Fig. 11 and described above, except that the drive plates and the pickup plates of each finger detector are curved to match the contour of a typical finger end. In particular, rate sensor 112 includes differential finger detectors 1220, 1222, ... 1230. Finger detector 1220 includes a curved drive plate 1240 and curved pickup plates 1242 and 1244 located on opposite sides of drive plate 1240. Pickup plate 1242 is spaced from drive plate 1240 by sensor gap 1250, and pickup plate 1244 is spaced from drive plate 1240 by sensor gap 1252. The remaining finger detectors have a similar construction. The curved plates of the finger detectors improve the signal-to-noise ratio of the differential rate sensor. It will be understood that different curvatures and shapes of the drive plates and pickup plates may be utilized for sensing objects other than fingers.

[0069] Another embodiment of a differential rate sensor is shown in Fig. 13. In this embodiment, a single drive plate 1302 has a serpentine configuration between

a comb-like array of pickup plates. In other respects, rate sensor of Fig. 13 is similar to the differential rate sensor of Fig. 11. Referring to Fig. 13, differential rate sensor 112 includes differential finger detectors 1320, 1322, 1324, ... 1330. Each finger detector includes first and second pickup plates positioned on opposite sides of the respective drive plate. For example, finger detector 1320 includes a section of serpentine drive plate 1302 and pickup plates 1342 and 1344 positioned on opposite sides of that section of drive plate 1302. Pickup plate 1342 is spaced from drive plate 1302 by sensor gap 1350, and pickup plate 1344 is spaced from drive plate 1302 by sensor gap 1352. The remaining finger detectors have a similar construction. In the embodiment of Fig. 13, a common serpentine drive plate is utilized. In addition, the first pickup plates of the finger detectors are commonly connected, and the second pickup plates of the finger detectors are commonly connected.

[0070] As a finger is initially swiped across the differential rate sensor of Fig. 13, all the finger detectors 1320, 1322, 1324, ... 1330 are covered by dielectric and no net differential signal is produced in the pickup plates 1342 and 1344. As soon as the end of the finger swipes past the first sensor gap 1350 and is between the first sensor gap 1350 and the second sensor gap 1352, a net differential signal appears on the pickup plates 1342 and 1344. This phenomenon is repeated as the end of passes the next finger detector 1322 until the end of the finger reaches the last finger detector 1330.

[0071] Another embodiment of the rate sensor 112 is shown in Fig. 14. The embodiment of Fig. 14 is similar to the embodiment of Fig. 13, except that the drive plates and the pickup plates of each finger detector are curved to match a typical finger end. In particular, rate sensor 112 includes finger detectors 1420, 1422, 1424, ... 1430. Each finger detector includes a curved drive plate and first and second pickup plates located on opposite sides of the drive plate. For example, finger detector 1420 includes curved drive plate 1440 and curved pickup plates 1442 and 1444 on opposite sides of drive plate 1440.

[0072] In each embodiment of the rate sensor, the drive plates and the pickup plates of each finger detector are preferably coplanar. Furthermore, the rate sensor and the image sensor can be fabricated on a single substrate so that the image drive plates and the image pickup plate of the image sensor and the rate drive plates and the rate pickup plates of the rate sensor are all substantially coplanar.

[0073] Fig. 15 is a block diagram of an embodiment of rate sensing circuit 122 (Fig. 1A) and microprocessor and memory 130 for deriving rate information from the rate sensor embodiments of Figs. 9 and 10. Rate sensor mux scanning logic 1502 sequentially asserts its output lines in response to signals from microprocessor and memory 130. In response to an asserted output signal from rate sensor mux scanning logic 1502, a switch 1504 closes, thereby gating the clock signal from master

clock 302 to a low impedance buffer 1506. A signal burst 1508, derived from the clock signal, is output from the selected switch 1504 and passes through buffer 1506 to the drive plate of one of the finger detectors 1010, 1012, ... 1016.

[0074] In the embodiments shown in Figs. 9 and 10, pickup plate 116 serves as an image sensor pickup plate and as a rate sensor pickup plate. The output of pickup plate 116 is supplied to a band pass filter 1510. Band pass filter 1510 has a center frequency of the clock signal. The filtered signal is provided to a mixer 1512, where it is multiplied by the clock signal. As described in connection with Fig. 3, the mixer functions as a synchronous envelope detector. The pulse amplitude modulated signal output by mixer 1512 is supplied through a low pass filter 1514 to a pulse detector 1516. Pulse detector 1516 supplies a trigger signal to a rate sensor event timer 1818, shown in Fig. 18. The pulse detector 1516 may be implemented as a comparator with a threshold that is programmed by the microprocessor, or in software by sampling the rate sensor output with an analog-to-digital converter and comparing the result to a digital threshold. The threshold of pulse detector 1516 is adjusted to generate an output trigger signal when the finger end passes each of the finger detectors.

[0075] Fig. 16 is a block diagram of an embodiment of rate sensing circuit 122 (Fig. 1A) and microprocessor and memory 130 for deriving rate information from the differential rate sensor embodiments of Figs. 11 and 12. The rate sensing circuit of Fig. 16 differs from the rate sensing circuit of Fig. 15 in that the differential rate sensor has a differential output. In particular, the commonly connected pickup lines 1160 and 1162 of finger detectors 1120, 1122, ... 1130 are connected to a differential band pass filter 1602. The outputs of band pass filter 1602 are connected to inputs of a differential mixer 1604. Mixer 1604 multiplies the differential inputs by the clock-signal to obtain a baseband pulse that represents the envelope of the capacitively coupled signal bursts. As in the embodiment of Fig. 15, mixer 1604 functions as a synchronous envelope detector. The output of mixer 1604 is supplied through low pass filter 1514 to pulse detector 1516 for determining rate information as described above.

[0076] Fig. 17 is a block diagram of an embodiment of rate sensing circuit 122 (Fig. 1A) and microprocessor and memory 130 deriving rate information from the differential rate sensor embodiments of Figs. 13 and 14. As described above, the embodiments of Figs. 13 and 14 utilize a single drive plate having a serpentine configuration. The rate sensing circuit of Fig. 17 differs from the rate sensing circuit of Fig. 16 in that a single drive circuit is required for the serpentine drive plate 1302. A single switch 1710 gates the clock signal, in response to a control signal from microprocessor and memory 130, through a buffer 1712 to supply a signal burst 1714 to serpentine drive plate 1302. The outputs of the rate sensor on pickup lines 1160 and 1162 are provided to

differential band pass filter 1602 as in the embodiment of Fig. 16.

[0077] It will be understood that the rate sensing circuit may use the same master clock as the image sensing circuit or a different clock having a different frequency that is selected to optimize rate sensing.

[0078] Fig. 18 is a block diagram of a data acquisition and control processor in accordance with an embodiment of the invention. Microprocessor and memory 130 and its connection to the image sensing circuit and the rate sensing circuit are shown in Fig. 18. Microprocessor and memory 130 may include a microprocessor 1804 connected by a memory bus 1814 to a line buffer 1808, a rate sensor event memory 1810 and an image buffer memory 1812. Line buffer memory 1808 may store image data for a single line scan of the image sensor. Image buffer memory 1812 may store one or more entire fingerprint images. Rate sensor event memory 1810 may store finger detector numbers and rate sensor event times for determining finger speed. Microprocessor 1804 may be connected by an I/O bus 1802 to mux scanning logic 304 (Fig. 3) of the image sensing circuit and A/D converter 324 of the image sensing circuit. Microprocessor 1804 may further be connected via I/O bus 1802 to rate sensor mux scanning logic 1502 of the rate sensing circuit (Fig. 15) and to rate sensor event timer 1818, which determines the time delay between rate sensor events. A scan timer 1806 connected to I/O bus 1802 is used to initiate line scan sequences.

[0079] Fig. 19 is a flow diagram of an embodiment of a rate sensor method for use with the single-ended rate sensor embodiments of Figs. 9 and 10 and the rate sensing circuit of Fig. 15. In step 1902, background signal levels from each rate sensor finger detector are collected. In step 1904, the rate sensor event timer 1818 (Fig. 18) is started. Then, in step 1906, a rate event number T is set to zero. An active rate sensor number R is set to 1 in step 1908. The finger detector corresponding to the active rate sensor number R is activated in step 1910. After the capacitively coupled drive signal is detected and processed, the pulse detector 1516 output is read in step 1912, and the background signal level is subtracted in step 1914. If a pulse is detected step 1916, the active finger detector number and event time are stored in the rate event buffer 1810 shown in Fig. 18. In step 1920, the rate event number T is incremented. If the active finger detector is determined in step 1922 to be the last finger detector in the rate sensor, the method exits. If the active finger detector is not the last finger detector, the active rate sensor number R is incremented in step 1924, and the method returns to step 1910 for continued execution. If a pulse was not detected in step 1916 the method returns to step 1910 for continued execution.

[0080] It will be understood that the method of Fig. 19 scans each finger detector of the rate sensor sequentially until a single transition is detected, and then proceeds to the next finger detector. In other embodiments,

the method may scan all finger detectors, and determine if there are transitions on any of the finger detectors. This advantageously provides detection of missed transitions.

[0081] Fig. 20 is a flow diagram of an embodiment of a rate sensor method for use with the differential rate sensor embodiments of Figs. 11 and 12 and the rate sensing circuit of Fig. 16. The initialization procedure of steps 2004, 2006 and 2008 is similar to that of Fig. 19, except that background signal levels are not detected. As with the embodiment of Fig. 19, the finger detector corresponding to the active rate sense drive plate number is activated in step 2010, and the pulse detector 1516 output is read in step 2012. If a pulse is detected in step 2014, the active finger detector number R and event time are stored in the rate event buffer 1810 in step 2016. The rate event number T is subsequently incremented in step 2018. If the active plate number is determined in step 2020 to be to the last finger detector in the rate sensor, the method exits. If the active finger detector is not the last finger detector, the active rate sensor number R is incremented in step 2022 and the method returns to step 2010 for further processing. If a pulse was not detected in step 2014 the method returns to step 2010 for continued execution.

[0082] It will be understood that the method of Fig. 20 scans each finger detector of the rate sensor sequentially until a single transition is detected, and then proceeds to the next finger detector. In other embodiments, the method may scan all finger detectors, and determine if there are transitions on any of the finger detectors. This advantageously provides detection of missed transitions.

[0083] Fig. 21 is a flow diagram of an embodiment of a rate sensor method for use with the differential rate sensor embodiments of Figs. 13 and 14 and the rate sensing circuit of Fig. 17. The rate sensor event timer and rate event number T are initialized in steps 2104 and 2106, respectively. In step 2108, a rate event count C is initialized. In step 2110, rate sensor pulse detector 1516 is read after the serpentine drive plate 1302 has been activated with a drive signal and the differential output of the rate sensor has been detected and processed. If a pulse is detected in step 2112, the rate event time is stored in the rate event buffer 1810 in step 2114, the rate event number T is incremented in step 2116, and the rate event count C is incremented in step 2118. If the rate event count C is determined in step 2120 to be equal to the number of finger detectors in the rate sensor, the method exits. If the rate event count C is not equal to the number of finger detectors in the rate sensor, or if a pulse is not detected in step 2112, then the method returns to step 2110 for further processing.

[0084] Fig. 22 is a flow chart of an image line acquisition process in accordance with an embodiment of the present invention. In step 2204, a drive plate number N is initialized. The drive plate 114 corresponding to the plate number N is activated, and all other drive plates

114 are driven to ground in step 2206. Following detection and processing of the capacitively coupled drive signal, the output of A/D converter 324 (Fig. 3) is read in step 2208. The value read from analog-to-digital converter 324 is stored in the line buffer 1808 (Fig. 18) in step 2210. The plate number N is incremented in step 2212, and if all of the drive plates 114 in the image sensor are determined in step 2214 to have been activated, the process ends. If all drive plates in the image sensor have not been activated, the method returns to step 2206 for continued execution.

[0085] Fig. 23 is a flow chart of an image acquisition method that utilizes fixed time interval line sampling in accordance with an embodiment of the invention. In step 2304, an image line variable L is initialized. The line scan timer 1806 (Fig. 18) is initialized to a desired line scan time in step 2306. Subsequently, a next tick event from timer 1806 is enabled in step 2308. In step 2310, the process waits for a tick event from line scan timer 1806. After a tick event occurs, the line scan timer 1806 is restarted in step 2312. In step 2314, a line of image data is acquired, for example, in accordance with the line acquisition method described above in connection with Fig. 22. When a line of image data has been acquired, the contents of line buffer 1808 (Fig. 18) are stored in image buffer 1812 (Fig. 18). In step 2318, the image line variable L is incremented. If the entire image has been acquired (step 2320), i.e. L = the number of lines in the complete image, the process is complete. If the entire image has not been acquired, the process returns to step 2308 for further processing.

[0086] In one embodiment, an image acquired by this method is advantageously resampled based on the rate data gathered in the rate sensor event memory 1810 to produce an image whose lines are spaced at fixed distance intervals.

[0087] Fig. 24 illustrates a flow chart of another embodiment of an image acquisition method in accordance with the invention. In this embodiment, the line sampling time is controlled by a rate sensor. The image line number L is initialized in step 2404, and the line scan timer 1806 is set to the desired line scan time in step 2406. In step 2408, the next tick event from line scan timer 1806 is enabled. In step 2410, the process waits for a tick event from line scan timer 1806. If any rate events have been detected in step 2412 since the last line was acquired, a new line interval is computed from the most recent rate data in step 2414. The line scan timer 1806 is then set to the new line interval in step 2416. Subsequently, or if any rate events were not detected between the prior line acquisition and the tick event, line scan timer 1806 is restarted in step 2418. In step 2420, a line is acquired, for example, in accordance with the line acquisition method described above in connection with Fig. 22. The contents of line buffer 1808 (Fig. 18) are then stored in image buffer 1812 in step 2422. Then, the image line number L is incremented in step 2424. If the entire image has been acquired (step

2426), then the process is complete. If the entire image has not been acquired, the method returns to step 2408 for further processing.

[0088] Having thus described several illustrative embodiments of the invention, various alterations, modifications and improvements will readily occur to those skilled in the art.

[0089] Accordingly, the foregoing description is by way of example only as defined in the following claims.

Claims

1. Image sensing apparatus comprising:

an image pickup plate (116) disposed generally orthogonally to a direction of movement of an object; and

a plurality of image drive plates (114) in spaced relation to said image pickup plate (116) to define a plurality of sensor gaps (118) between respective image drive plates (114) and said image pickup plate (116), wherein features of the object passing over said sensor gaps (118) produce a change in capacitance between respective image drive plates (114) and said image pickup plate (116).

2. Image sensing apparatus as defined in claim 1, wherein said pickup plate and said plurality of image drive plates are dimensioned and spaced for sensing a fingerprint.

3. Image sensing apparatus as defined in claim 2, wherein a spacing between each of said image drive plates and said image pickup plate is less than one half of the ridge spacing on a typical fingerprint.

4. Image sensing apparatus as defined in claim 2, wherein a spacing between adjacent ones of said image drive plates is less than one half of the ridge spacing on a typical fingerprint.

5. Image sensing apparatus as defined in claim 1, wherein said image drive plates comprise parallel conductors disposed perpendicular to said image pickup plate and spaced from said image pickup plate by respective sensor gaps.

6. Image sensing apparatus as defined in claim 1, wherein said pickup plate comprises two or more image pickup plates disposed generally orthogonally to the direction of movement of the object.

7. Image sensing apparatus as defined in claim 2, including at least 250 image drive plates.

8. Image sensing apparatus as defined in claim 1, fur-

ther comprising a substrate, wherein said image pickup plate and said plurality of image drive plates comprise conductive traces on said substrate.

9. Image sensing apparatus as defined in claim 8, wherein said substrate comprises a printed circuit board.

10. Image sensing apparatus as defined in Claim 8, wherein said substrate comprises a flexible substrate.

11. Image sensing apparatus as defined in claim 10, further comprising a substrate support, wherein said flexible substrate is affixed to said substrate support and wherein said substrate support has a contour selected to substantially match the contour of a typical finger.

12. Image sensing apparatus as defined in Claim 1, further comprising:

an excitation circuit for sequentially energizing said image drive plates with drive signals, and a detection circuit for detecting the drive signals capacitively coupled from said image drive plates to said image pickup plate to provide image signals.

13. Image sensing apparatus as defined in claim 12, wherein said drive signals comprise sequential signal bursts applied to respective ones of said image drive plates.

14. Image sensing apparatus as defined in claim 13, wherein said excitation circuit includes circuitry for coupling non-energized image drive plates to a reference potential.

15. Image sensing apparatus as defined in claim 13, wherein said signal bursts comprise bursts of a clock signal.

16. Image sensing apparatus as defined in Claim 13, wherein said detection circuit comprises a synchronous detector for providing pulses in response to the detected signal bursts.

17. Imagesensing apparatus as defined in claim 16, further comprising an analog-to-digital converter for converting said pulses to digital values, a memory and a processor for storing the digital values in said memory.

18. Image sensing apparatus as defined in claim 17, wherein said processor initiates a plurality of sequential line scans of said image drive plates to provide a plurality of line scans along lines of the mov-

ing object.

19. Image sensing apparatus as defined in claim 12, wherein said detection circuit includes an amplifier for receiving the capacitively coupled drive signals, said amplifier having a gain that is an inverse function of the amplitude of the capacitively coupled drive signals.

20. A fingerprint sensing system comprising:

an image sensor (110) comprising a linear array of capacitive sensors for capacitive sensing of ridge peaks and ridge valleys of a fingerprint on a moving finger, said image sensor comprising:

an image pickup plate (116) disposed generally orthogonally to a direction of movement of the finger; and

a plurality of image drive plates (114) in spaced relation to said image pickup plate to define a plurality of sensor gaps (118) between respective image drive plates (114) and said image pickup plate (116), wherein ridge peaks and ridge valleys of the fingerprint passing over said sensor gaps (118) produce a change in capacitance

between respective image drive plates (114) and said image pickup plate (116); a velocity sensor (112) for sensing a speed of the finger as it moves across said image sensor; and

a sensor circuit (108) for excitation of said image sensor with image drive signals (104) and for detection (106) of image signals in response to said image drive signals (104), for excitation of said velocity sensor (112) with velocity drive signals (105) and for detection (107) of velocity signals in response to said velocity drive signals (105), and for coordinating said image signals (106) and said velocity signals (107) to provide a fingerprint image.

21. A fingerprint sensing system as defined in Claim 20, wherein a spacing between each of said image drive plates and said image pickup plate is less than one half of the ridge spacing on a typical fingerprint.

22. A fingerprint sensing system as defined in claim 20, wherein a spacing between adjacent ones of said image drive plates is less than one half of the ridge spacing on a typical fingerprint.

23. A fingerprint sensing system as defined in Claim 20, wherein said image drive plates comprise parallel conductors disposed perpendicular to said image

pickup plate and spaced from said image pickup plate by respective sensor gaps.

24. A fingerprint sensing system as defined in claim 20, wherein said image pickup plate comprises two or more image pickup plates disposed generally orthogonally to the direction of movement of the finger.

25. A fingerprint sensing system as defined in claim 20, including at least 250 image drive plates.

26. A fingerprint sensing system as defined in Claim 20, further comprising a substrate, wherein said image pickup plate and said plurality of image drive plates comprise conductive traces on said substrate.

27. A fingerprint sensing system as defined in claim 26, wherein said substrate comprises a flexible substrate.

28. A fingerprint sensing system as defined in Claim 27, further comprising a substrate support, wherein said flexible substrate is affixed to said substrate support and wherein said substrate support has a contour selected to substantially match the contour of a typical finger.

29. A fingerprint sensing system as defined in claim 20, wherein said sensor circuit comprises:

an excitation circuit for sequentially energizing said image drive plates with said image drive signals, and

a detection circuit for detecting the image drive signals capacitively coupled from said image drive plates to said image pickup plate to provide said image signals.

30. A fingerprint sensing system as defined in claim 29, wherein said image drive signals comprise sequential signal bursts applied to respective ones of said image drive plates.

31. A fingerprint sensing system as defined in claim 30, wherein said excitation circuit includes circuitry for coupling non-energized image drive plates to a reference potential.

32. A fingerprint sensing system as defined in claim 30, wherein said detection circuit comprises a synchronous detector for providing pulsed image signals.

33. A fingerprint sensing system as defined in claim 32, wherein said sensor circuit further comprises an analog-to-digital converter for converting said pulsed image signals to digital values, a memory and a processor for storing the digital values in said mem-

ory.

34. A fingerprint sensing system as defined in claim 33, wherein said processor initiates a plurality of sequential line scans of said image drive plates to provide a plurality of line scans along lines of the moving finger. 5
35. A fingerprint sensing system as defined in claim 29, wherein said detection circuit includes an amplifier for receiving the capacitively coupled image drive signals, said amplifier having a gain that is an inverse function of the amplitude of the capacitively coupled image drive signals. 10
36. A fingerprint sensing system as defined in claim 20, wherein said velocity sensor comprises: 15
- two or more finger detectors spaced apart along a direction of movement of the finger, each of said finger detectors including at least one velocity drive plate and at least one velocity pickup plate, wherein an end of the finger passing over each of said finger detectors produces a change in capacitance between respective velocity drive plates and velocity pickup plates. 20
37. A fingerprint sensing system as defined in claim 36, wherein the velocity drive plate and the velocity pickup plate of each of said finger detectors are disposed generally orthogonally to the direction of movement of the finger. 25
38. A fingerprint sensing system as defined in claim 36, wherein the rate pickup plates of said finger detectors are commonly connected. 30
39. A fingerprint sensing system as defined in claim 36, wherein each of said finger detectors includes first and second velocity pickup plates disposed on opposite sides of the velocity drive plate to form a differential capacitive sensor. 35
40. A fingerprint sensing system as defined in claim 39, wherein the velocity drive plates of said finger detectors are commonly connected. 40
41. A fingerprint sensing system as defined in claim 36, wherein the velocity drive plates and the velocity pickup plates of said finger detectors are curved to substantially match the curve of a typical finger end. 45
42. A fingerprint sensing system as defined in claim 36, further comprising a substrate, wherein said velocity drive plates and said velocity pickup plates comprise conductive traces on said substrate. 50
43. A fingerprint sensing system as defined in claim 36,

further comprising a flexible substrate, wherein said velocity drive plates and said velocity pickup plates comprise conductive traces on said flexible substrate.

44. A fingerprint sensing system as defined in claim 36, wherein said sensor circuit comprises: 5
- an excitation circuit for energizing the velocity drive plates of said finger detectors with said velocity drive signals, and
a detection circuit for detecting the velocity drive signals capacitively coupled from the velocity drive plate to the velocity pickup plate of each of said finger detectors to provide said velocity signals. 10
45. A fingerprint sensing system as defined in claim 44, wherein said velocity drive signals comprise signal bursts. 15
46. A fingerprint sensing system as defined in claim 45, wherein said detection circuit comprises a synchronous detector. 20
47. A fingerprint sensing system as defined in claim 44, wherein said sensor circuit further comprises a processing circuit for detecting a time delay between said velocity signals from said finger detectors, wherein said time delay between said velocity signals is representative of the speed of the finger. 25
48. A fingerprint sensing system as defined in claim 20, further comprising a substrate, wherein said image sensor and said velocity sensor are fabricated on said substrate. 30
49. A fingerprint sensing system as defined in claim 48, wherein said substrate comprises a flexible substrate. 35
50. A fingerprint sensing system as defined in claim 48, wherein said sensor circuit is mounted on said substrate. 40
51. A fingerprint sensing method, comprising the steps of: 45
- capacitively sensing ridge peaks and ridge valleys of a fingerprint on a swiped finger (120) with an array of capacitive sensors and providing image signals representative of a line of the fingerprint, the array of capacitive sensors comprising an image pickup plate (116) disposed generally orthogonally to a direction of movement of the finger and a plurality of image drive plates (114) in spaced relation to the image pickup plate to define a plurality of sensor gaps 50

(118) between respective image drive plates (114) and the image pickup plate (116), wherein the ridge peaks and ridge valleys of the fingerprint passing over said sensor gaps (118) produce a change in capacitance between respective image drive plates (114) and said image pickup plate (116); and
acquiring from the array of capacitive sensors image signals representative of multiple lines of the fingerprint to provide a fingerprint image.

52. A fingerprint sensing method as defined in claim 51, further comprising:

sensing a speed of the finger as it is swiped across the array of capacitive sensors and providing velocity signals; and
coordinating the image signals and the velocity signals to provide the fingerprint image.

53. Image sensing apparatus as defined in claim 1, wherein said image pickup plate and said plurality of image drive plates are substantially coplanar.

54. A fingerprint sensing system as defined in claim 20, wherein said image pickup plate and said plurality of image drive plates are substantially coplanar.

55. A fingerprint sensing system as defined in claim 36, wherein the velocity drive plate and the velocity pickup plate of each of said finger detectors are substantially coplanar.

Patentansprüche

1. Bildabtasteinrichtung, welche aufweist:

eine Bildaufnehmerplatte (116), die im Wesentlichen orthogonal zur Richtung der Bewegung eines Objekts angeordnet ist; und

mehrere Bildtreiberplatten (114) beabstandet von der Bildaufnehmerplatte (116) zur Ausbildung mehrerer Sensorspalte (118) zwischen den Bildtreiberplatten (114) und der Bildaufnehmerplatte (116), wobei Merkmale des Objekts, das über die Sensorspalte (118) gelangt, eine Änderung der Kapazität zwischen den Bildtreiberplatten (114) und der Bildaufnehmerplatte (116) hervorrufen.

2. Bildabtasteinrichtung nach Anspruch 1, bei welcher die Aufnehmerplatte und die mehreren Bildtreiberplatten Abmessungen und Abstände zur Abtastung eines Fingerabdrucks aufweisen.

3. Bildabtasteinrichtung nach Anspruch 2, bei welcher

ein Abstand zwischen jeder der Bildtreiberplatten und der Bildaufnehmerplatte kleiner ist als die Hälfte des Abstandes der Erhöhungen auf einem typischen Fingerabdruck.

4. Bildabtasteinrichtung nach Anspruch 2, bei welcher ein Abstand zwischen benachbarten Bildtreiberplatten kleiner ist als die Hälfte des Abstandes der Erhöhungen auf einem typischen Fingerabdruck.

5. Bildabtasteinrichtung nach Anspruch 1, bei welcher die Bildtreiberplatten parallele Leiter aufweisen, die senkrecht zu der Bildaufnehmerplatte angeordnet ist, und von der Bildaufnehmerplatte durch jeweilige Sensorspalte getrennt sind.

6. Bildabtasteinrichtung nach Anspruch 1, bei welcher die Aufnehmerplatte zwei oder mehr Bildaufnehmerplatte aufweist, die im Wesentlichen orthogonal zur Richtung der Bewegung des Objekts angeordnet sind.

7. Bildabtasteinrichtung nach Anspruch 2, welche zumindest 250 Bildtreiberplatten aufweist.

8. Bildabtasteinrichtung nach Anspruch 1, welche weiterhin ein Substrat aufweist, wobei die Bildaufnehmerplatte und die mehreren Bildtreiberplatten leitfähige Linienzüge auf dem Substrat aufweisen.

9. Bildabtasteinrichtung nach Anspruch 8, bei welcher das Substrat eine Leiterplatte aufweist.

10. Bildabtasteinrichtung nach Anspruch 8, bei welcher das Substrat ein flexibles Substrat aufweist.

11. Bildabtasteinrichtung nach Anspruch 10, welche weiterhin eine Substrathalterung aufweist, wobei das flexible Substrat an der Substrathalterung befestigt ist, und die Substrathalterung eine Kontur aufweist, die so ausgewählt ist, dass sie im Wesentlichen an die Kontur eines typischen Fingers angepasst ist.

12. Bildabtasteinrichtung nach Anspruch 1, welche weiterhin aufweist:

eine Erregerschaltung zur aufeinanderfolgenden Energieversorgung der Bildtreiberplatten mit Treibersignalen, und
eine Detektorschaltung zur Erfassung der Treibersignale, die kapazitiv von den Bildtreiberplatten an die Bildaufnehmerplatte gekoppelt werden, um Bildsignale zur Verfügung zu stellen.

13. Bildabtasteinrichtung nach Anspruch 12, bei welcher die Treibersignale aufeinanderfolgende Si-

- gnalbursts aufweisen, die an die jeweiligen Bildtreiberplatten angelegt werden.
14. Bildabtasteinrichtung nach Anspruch 13, bei welcher die Erregerschaltung eine Schaltung zum Kop- 5
peln nicht mit Energie versorgter Bildtreiberplatten an ein Bezugspotential aufweist.
15. Bildabtasteinrichtung nach Anspruch 13, bei welcher die Signalbursts Bursts eines Taktsignals auf- 10
weisen.
16. Bildabtasteinrichtung nach Anspruch 13, bei welcher die Detektorschaltung einen Synchrondetek- 15
tor zur Bereitstellung von Impulsen in Reaktion auf die erfassten Signalbursts aufweist.
17. Bildabtasteinrichtung nach Anspruch 16, welche weiterhin einen Analog/Digitalwandler zur Um- 20
wandlung der Impulse in Digitalwerte aufweist, einen Speicher, und einen Prozessor, zum Speichern der Digitalwerte in dem Speicher.
18. Bildabtasteinrichtung nach Anspruch 17, bei welcher der Prozessor mehrere aufeinanderfolgende 25
Zeilenscans der Bildtreiberplatten einleitet, um mehrere Zeilenscans entlang Zeilen des sich bewegend-
en Objekts zur Verfügung zu stellen.
19. Bildabtasteinrichtung nach Anspruch 12, bei welcher die Detektorschaltung einen Verstärker zum 30
Empfangen der kapazitiv gekoppelten Treibersignale aufweist, und der Verstärker eine Verstärkung aufweist, welche eine inverse Funktion der Amplitude der kapazitiv gekoppelten Treibersignale 35
aufweist.
20. Fingerabdruckabtastsystem, welches aufweist:
- einen Bildsensor (110), der eine lineare, regel- 40
mäßige Anordnung aus kapazitiven Sensoren zur kapazitiven Abtastung der Spitzen der Erhöhungen und der Täler der Erhöhungen eines Fingerabdrucks auf einem sich bewegenden Finger aufweist, wobei der Bildsensor aufweist:
- eine Bildaufnehmerplatte (116), die im Wesentlichen orthogonal zur Richtung der Bewegung des Fingers angeordnet ist; und
- mehrere Bildtreiberplatten (114) beabstan- 50
det von der Bildaufnehmerplatte, zur Ausbildung mehrerer Sensorspalte (118) zwischen den Bildtreiberplatten (114) und der Bildaufnehmerplatte (116), wobei Spitzen 55
und Täler der Erhöhungen des Fingerabdrucks, die über die Sensorspalte (118) gelangen, eine Änderung der Kapazität zwischen den Bildtreiberplatten (114) und der Bildaufnehmerplatte (116) erzeugen;
- einen Geschwindigkeitssensor (112) zur Erfassung der Geschwindigkeit des Fingers, wenn sich dieser über den Bildsensor bewegt; und
- eine Sensorschaltung (108) zur Erregung des Bildsensors mit Bildtreibersignalen (104) und zur Erfassung (106) von Bildsignalen in Reaktion auf die Bildtreibersignale (104), zur Erregung des Geschwindigkeitssensors (112) mit Geschwindigkeitstreibersignalen (105) und zur Erfassung (107) von Geschwindigkeitssignalen in Reaktion auf die Geschwindigkeitstreibersignale (105), und zum Koordinieren der Bildsignale (106) und der Geschwindigkeitssignale (107) zur Bereitstellung eines Fingerabdruckbilds.
21. Fingerabdruckabtastsystem nach Anspruch 20, bei welchem der Abstand zwischen jeder der Bildtreiberplatten und der Bildaufnehmerplatte kleiner ist als die Hälfte des Abstandes der Erhöhungen auf einem typischen Fingerabdruck.
22. Fingerabdruckabtastsystem nach Anspruch 20, bei welchem der Abstand zwischen benachbarten Bildtreiberplatten kleiner ist als die Hälfte des Abstandes der Erhöhungen auf einem typischen Fingerabdruck.
23. Fingerabdruckabtastsystem nach Anspruch 20, bei welchem die Bildtreiberplatten parallele Leiter aufweisen, die senkrecht zu der Bildaufnehmerplatte angeordnet sind, und von der Bildaufnehmerplatte durch jeweilige Sensorspalte beabstandet sind.
24. Fingerabdruckabtastsystem nach Anspruch 20, bei welchem die Bildaufnehmerplatte zwei oder mehr Bildaufnehmerplatten aufweist, die im Wesentlichen orthogonal zur Richtung der Bewegung des Fingers angeordnet sind.
25. Fingerabdruckabtastsystem nach Anspruch 20, welches zumindest 250 Bildtreiberplatten aufweist.
26. Fingerabdruckabtastsystem nach Anspruch 20, welches weiterhin ein Substrat aufweist, wobei die Bildaufnehmerplatte und die mehreren Bildtreiberplatten leitfähige Linienzüge auf dem Substrat aufweisen.
27. Fingerabdruckabtastsystem nach Anspruch 26, bei welchem das Substrat ein flexibles Substrat aufweist.

28. Fingerabdruckabtastsystem nach Anspruch 27, welches weiterhin eine Substrathalterung aufweist, wobei das flexible Substrat an der Substrathalterung befestigt ist, und die Substrathalterung eine Kontur aufweist, die so ausgewählt ist, dass sie im Wesentlichen an die Kontur eines typischen Fingers angepasst ist. 5
29. Fingerabdruckabtastsystem nach Anspruch 20, bei welchem die Sensorschaltung aufweist: 10
- eine Erregerschaltung zur aufeinanderfolgenden Energieversorgung der Bildtreiberplatten mit den Bildtreibersignalen und
- eine Detektorschaltung zur Erfassung der Bildtreibersignale, die kapazitiv von den Bildtreiberplatten an die Bildaufnehmerplatte gekoppelt werden, um die Bildsignale zur Verfügung zu stellen. 15
30. Fingerabdruckabtastsystem nach Anspruch 29, bei welchem die Bildtreibersignale aufeinanderfolgende Signalturms aufweisen, die an die jeweiligen Bildtreiberplatten angelegt werden. 20
31. Fingerabdruckabtastsystem nach Anspruch 30, bei welchem die Erregerschaltung eine Schaltung zum Koppeln nicht mit Energie versorgter Bildtreiberplatten an ein Bezugspotential aufweist. 25
32. Fingerabdruckabtastsystem nach Anspruch 30, bei welchem die Detektorschaltung einen Synchrondetektor zur Bereitstellung gepulster Bildsignale aufweist. 30
33. Fingerabdruckabtastsystem nach Anspruch 32, bei welchem die Sensorschaltung weiterhin einen Analog/Digitalwandler zum Umwandeln der gepulsten Bildsignale in Digitalwerte aufweist, einen Speicher und einen Prozessor zum Speichern der Digitalwerte in dem Speicher. 35
34. Fingerabdruckabtastsystem nach Anspruch 33, bei welchem der Prozessor mehrere aufeinanderfolgende Zeilenscans der Bildtreiberplatten einleitet, um mehrere Zeilenscans entlang Linien des sich bewegenden Fingers zur Verfügung zu stellen. 40
35. Fingerabdruckabtastsystem nach Anspruch 29, bei welchem die Detektorschaltung einen Verstärker zum Empfangen der kapazitiv gekoppelten Bildtreibersignale aufweist, und der Verstärker eine Verstärkung aufweist, welche eine inverse Funktion der Amplitude der kapazitiv gekoppelten Bildtreibersignale ist. 45
36. Fingerabdruckabtastsystem nach Anspruch 20, bei welchem der Geschwindigkeitssensor aufweist: 50
- zwei oder mehr Fingerdetektoren, die entlang einer Richtung der Bewegung des Fingers beabstandet sind, wobei jeder der Fingerdetektoren zumindest eine Geschwindigkeitstreiberplatte und zumindest eine Geschwindigkeitsaufnehmerplatte aufweist, wobei ein Ende des Fingers, das über jeden der Fingerdetektoren gelangt, eine Änderung der Kapazität zwischen jeweiligen Geschwindigkeitstreiberplatten und Geschwindigkeitsaufnehmerplatten erzeugt. 55
37. Fingerabdruckabtastsystem nach Anspruch 36, bei welchem die Geschwindigkeitstreiberplatte und die Geschwindigkeitsaufnehmerplatte jedes der Fingerdetektoren im Wesentlichen orthogonal zur Richtung der Bewegung des Fingers angeordnet sind. 60
38. Fingerabdruckabtastsystem nach Anspruch 36, bei welchem die Geschwindigkeitsaufnehmerplatten der Fingerdetektoren gemeinsam angeschlossen sind. 65
39. Fingerabdruckabtastsystem nach Anspruch 36, bei welchem jeder der Fingerdetektoren eine erste und eine zweite Geschwindigkeitsaufnehmerplatte aufweist, die auf entgegengesetzten Seiten der Geschwindigkeitstreiberplatte angeordnet sind, um einen differentiellen, kapazitiven Sensor auszubilden. 70
40. Fingerabdruckabtastsystem nach Anspruch 39, bei welchem die Geschwindigkeitstreiberplatten der Fingerdetektoren gemeinsam angeschlossen sind. 75
41. Fingerabdruckabtastsystem nach Anspruch 36, bei welchem die Geschwindigkeitstreiberplatten und die Geschwindigkeitsaufnehmerplatten der Fingerdetektoren so gekrümmt sind, dass sie im Wesentlichen an die Kurve eines typischen Fingerendes angepasst sind. 80
42. Fingerabdruckabtastsystem nach Anspruch 36, welches weiterhin ein Substrat aufweist, wobei die Geschwindigkeitstreiberplatten und die Geschwindigkeitsaufnehmerplatten leitfähige Linienzüge auf dem Substrat aufweisen. 85
43. Fingerabdruckabtastsystem nach Anspruch 36, welches weiterhin ein flexibles Substrat aufweist, wobei die Geschwindigkeitstreiberplatten und die Geschwindigkeitsaufnehmerplatten leitfähige Linienzüge auf dem flexiblen Substrat aufweisen. 90
44. Fingerabdruckabtastsystem nach Anspruch 36, bei welchem die Sensorschaltung aufweist: 95

eine Erregerschaltung zur Energieversorgung der Geschwindigkeitstreiberplatten der Fingerdetektoren mit den Geschwindigkeitstreibersignalen, und

eine Detektorschaltung zur Erfassung der Geschwindigkeitstreibersignale, die kapazitiv von der Geschwindigkeitstreiberplatte an die Geschwindigkeitsaufnehmerplatte jedes der Fingerdetektoren gekoppelt werden, um die Geschwindigkeitssignale zur Verfügung zu stellen.

45. Fingerabdruckabtastsystem nach Anspruch 44, bei welchem die Geschwindigkeitstreibersignale Signalmuster aufweisen.

46. Fingerabdruckabtastsystem nach Anspruch 45, bei welchem die Detektorschaltung einen Synchrondetektor aufweist.

47. Fingerabdruckabtastsystem nach Anspruch 44, bei welchem die Sensorschaltung weiterhin eine Verarbeitungsschaltung zur Erfassung einer Zeitverzögerung zwischen den Geschwindigkeitssignalen von den Fingerdetektoren aufweist, wobei die Zeitverzögerung zwischen den Geschwindigkeitssignalen repräsentativ für die Geschwindigkeit des Fingers ist.

48. Fingerabdruckabtastsystem nach Anspruch 20, welches weiterhin ein Substrat aufweist, wobei der Bildsensor und der Geschwindigkeitssensor auf dem Substrat hergestellt sind.

49. Fingerabdruckabtastsystem nach Anspruch 48, bei welchem das Substrat ein flexibles Substrat aufweist.

50. Fingerabdruckabtastsystem nach Anspruch 48, bei welchem die Sensorschaltung auf dem Substrat angebracht ist.

51. Fingerabdruckabtastverfahren mit folgenden Schritten:

kapazitives Abtasten von Spitzen von Erhöhungen und Tälern von Erhöhungen eines Fingerabdrucks auf einem überstrichenen Finger (120) mit einer regelmäßigen Anordnung aus kapazitiven Sensoren, und Bereitstellung von Bildsignalen, welche eine Zeile des Fingerabdrucks repräsentieren, wobei die regelmäßige Anordnung aus kapazitiven Sensoren eine Bildaufnehmerplatte (116) aufweist, die im Wesentlichen orthogonal zu einer Richtung der Bewegung des Fingers angeordnet ist, und mehrere Bildtreiberplatten (114) im Abstand zu

der Bildaufnehmerplatte, um mehrere Sensorspalte (118) zwischen den Bildtreiberplatten (114) und der Bildaufnehmerplatte (116) auszubilden, wobei die Spitzen der Erhöhungen und die Täler der Erhöhungen des Fingerabdrucks, der über die Sensorspalte (118) gelangt, eine Änderung der Kapazität zwischen den Bildtreiberplatten (114) und der Bildaufnehmerplatte (116) erzeugen; und

Akquirieren von Bildsignalen, welche mehrere Zeilen des Fingerabdrucks repräsentieren, von der regelmäßigen Anordnung kapazitiver Sensoren, um ein Fingerabdruckbild zur Verfügung zu stellen.

52. Fingerabdruckabtastverfahren nach Anspruch 51, bei welchem weiterhin vorgesehen sind:

Abtastung einer Geschwindigkeit des Fingers, wenn er über die regelmäßige Anordnung aus kapazitiven Sensoren streicht, und Bereitstellung von Geschwindigkeitssignalen; und Koordinieren der Bildsignale und der Geschwindigkeitssignale zur Bereitstellung des Fingerabdruckbilds.

53. Bildabtasteinrichtung nach Anspruch 1, bei welcher die Bildaufnehmerplatte und die mehreren Bildtreiberplatten im Wesentlichen koplanar verlaufen.

54. Fingerabdruckabtastsystem nach Anspruch 20, bei welchem die Bildaufnehmerplatte und die mehreren Bildtreiberplatten im Wesentlichen koplanar verlaufen.

55. Fingerabdruckabtastsystem nach Anspruch 36, bei welchem die Geschwindigkeitstreiberplatte und die Geschwindigkeitsaufnehmerplatte jedes der Fingerdetektoren im Wesentlichen koplanar verlaufen.

Revendications

1. Appareil de détection d'image comprenant :

une plaque de capture d'image (116) disposée en général orthogonalement à une direction de déplacement d'un objet ; et
une pluralité de plaques d'attaque d'image (114) en relation espacée avec ladite plaque de capture d'image (116) pour définir une pluralité d'espaces de capteur (118) entre les plaques d'attaque d'image (114) respectives et ladite plaque de capture d'image (116), dans lequel les caractéristiques de l'objet passant sur lesdits espaces de capteur (118) produisent un changement de la capacité entre les plaques

d'attaque d'image respectives (114) et ladite plaque de capture d'image (116).

2. Appareil de détection d'image selon la revendication 1, dans lequel ladite plaque de capture et ladite pluralité de plaques d'attaque d'image sont dimensionnées et espacées pour détecter une empreinte digitale. 5
3. Appareil de détection d'image selon la revendication 2, dans lequel un espacement entre chacune desdites plaques d'attaque d'image et de ladite plaque de capture d'image est inférieur à la moitié d'un espacement de motif sur une empreinte digitale typique. 10
4. Appareil de détection d'image selon la revendication 2, dans lequel un espacement entre des plaques adjacentes desdites plaques d'attaque d'image est inférieur à la moitié d'un espacement de motif sur une empreinte digitale typique. 20
5. Appareil de détection d'image selon la revendication 1, dans lequel lesdites plaques d'attaque d'image comprennent des conducteurs parallèles disposés perpendiculaires à ladite plaque de capture d'image et espacées de ladite plaque de capture d'image par les espaces de capteur respectifs. 25
6. Appareil de détection d'image selon la revendication 1, dans lequel ladite plaque de capture comprend deux ou plus plaques de capture d'image disposées généralement orthogonalement à la direction du déplacement de l'objet. 30
7. Appareil de détection d'image selon la revendication 2, incluant au moins 250 plaques d'attaque d'image. 35
8. Appareil de détection d'image selon la revendication 1, comprenant, en outre, un substrat, dans lequel ladite plaque de capture d'image et ladite pluralité de plaques d'attaque d'image comprennent des pistes conductrices sur ledit substrat. 40
9. Appareil de détection d'image selon la revendication 8, dans lequel ledit substrat comprend une carte de circuit imprimé. 45
10. Appareil de détection d'image selon la revendication 8, dans lequel ledit substrat comprend un substrat souple. 50
11. Appareil de détection d'image selon la revendication 10, comprenant, en outre, un support de substrat, dans lequel ledit substrat souple est fixé au dit support de substrat et dans lequel ledit support de substrat présente un contour choisi pour correspon-

dre sensiblement au contour d'un doigt typique.

12. Appareil de détection d'image selon la revendication 1, comprenant en outre :
 - un circuit d'excitation pour alimenter séquentiellement lesdites plaques d'attaque d'image avec des signaux d'attaque, et
 - un circuit de détection pour détecter les signaux d'attaque couplés capacitivement depuis lesdites plaques d'attaque d'image à ladite plaque de capture d'image pour délivrer des signaux d'image.
13. Appareil de détection d'image selon la revendication 12, dans lequel lesdits signaux d'attaque comprennent des rafales de signaux séquentiels appliquées aux plaques respectives desdites plaques d'attaque d'image.
14. Appareil de détection d'image selon la revendication 13, dans lequel ledit circuit d'excitation inclut des circuits pour coupler les plaques d'attaque d'image non alimentées à un potentiel de référence.
15. Appareil de détection d'image selon la revendication 13, dans lequel lesdites rafales de signaux comprennent des rafales d'un signal d'horloge.
16. Appareil de détection d'image selon la revendication 13, dans lequel ledit circuit de détection comprend un détecteur synchrone pour délivrer des impulsions en réponse aux rafales de signaux détectées.
17. Appareil de détection d'image selon la revendication 16, comprenant, en outre, un convertisseur analogique/numérique pour convertir lesdites impulsions en valeurs numériques, une mémoire et un processeur pour mémoriser les valeurs numériques dans ladite mémoire.
18. Appareil de détection d'image selon la revendication 17, dans lequel ledit processeur initie une pluralité de balayages de ligne séquentielle desdites plaques d'attaque d'image pour procurer une pluralité de balayages de ligne le long des lignes de l'objet en déplacement.
19. Appareil de détection d'image selon la revendication 12, dans lequel ledit circuit de détection inclut un amplificateur pour recevoir les signaux d'attaque capacitivement couplés, ledit amplificateur présentant un gain qui est une fonction inverse de l'amplitude des signaux d'attaque capacitivement couplés.
20. Système de détection d'empreinte digitale

comprenant :

un capteur d'image (110) comprenant une rangée linéaire de capteurs capacitifs pour détecter capacitivement des crêtes de motif et des vallées de motif d'une empreinte digitale sur un doigt en déplacement, ledit capteur d'image comprenant :

une plaque de capture d'image (116) disposée généralement orthogonalement à une direction de déplacement du doigt ; et une pluralité de plaques d'attaque d'image (114) en relation espacée avec ladite plaque de capture d'image pour définir une pluralité d'espaces de capteur (118) entre les plaques d'attaque d'image respectives (114) et ladite plaque de capture d'image (116), dans lequel les crêtes de motif et les vallées de motif de l'empreinte digitale passant sur lesdits espaces de capteur (118) produisent un changement de la capacité entre les plaques d'attaque d'image respectives (114) et ladite plaque de capture d'image (116) ;

un capteur de vitesse (112) pour détecter une vitesse du doigt à mesure qu'il se déplace à travers ledit capteur d'image ; et un circuit de capteur (108) pour excitation dudit capteur d'image avec des signaux d'attaque d'image (104) et pour détection (106) de signaux d'image en réponse aux dits signaux d'attaque d'image (104), pour excitation dudit capteur de vitesse (112) avec des signaux d'attaque de vitesse (105) et pour détection (107) de signaux de vitesse en réponse aux dits signaux d'attaque de vitesse (105), et pour coordonner lesdits signaux d'image (106) et lesdits signaux de vitesse (107) pour fournir une image de l'empreinte digitale.

21. Système de détection d'empreinte digitale selon la revendication 20, dans lequel un espacement entre chacune desdites plaques d'attaque d'image et ladite plaque de capture d'image est inférieur à la moitié d'un espacement de motif sur une empreinte digitale typique.

22. Système de détection d'empreinte digitale selon la revendication 20, dans lequel un espacement entre des plaques adjacentes desdites plaques d'attaque d'image est inférieur à la moitié d'un espacement de motif sur une empreinte digitale typique.

23. Système de détection d'empreinte digitale selon la revendication 20, dans lequel lesdites plaques d'attaque d'image comprennent des conducteurs paral-

lèles disposés perpendiculaires à ladite plaque de capture d'image et espacés de ladite plaque de capture d'image par les espaces de capture respectifs.

24. Système de détection d'empreinte digitale selon la revendication 20, dans lequel ladite plaque de capture d'image comprend deux ou plus plaques de capture d'image disposées généralement orthogonalement à la direction de déplacement du doigt.

25. Système de détection d'empreinte digitale selon la revendication 20, incluant au moins 250 plaques d'attaque d'image.

26. Système de détection d'empreinte digitale selon la revendication 20, comprenant, en outre, un substrat, dans lequel ladite plaque de capture d'image et ladite pluralité de plaques d'attaque d'image comprennent des pistes conductrices sur ledit substrat.

27. Système de détection d'empreinte digitale selon la revendication 26, dans lequel ledit substrat comprend un substrat souple.

28. Système de détection d'empreinte digitale selon la revendication 27, comprenant, en outre, un support de substrat, dans lequel ledit substrat souple est fixé au dit support de substrat et dans lequel ledit support de substrat présente un contour choisi pour correspondre sensiblement au contour d'un doigt typique.

29. Système de détection d'empreinte digitale selon la revendication 20, dans lequel ledit circuit de capteur comprend :

un circuit d'excitation pour alimenter séquentiellement lesdites plaques d'attaque d'image avec lesdits signaux d'attaque d'image, et un circuit de détection pour détecter les signaux d'attaque d'image couplés capacitivement depuis lesdites plaques d'attaque d'image à ladite plaque de capture d'image pour délivrer lesdits signaux d'image.

30. Système de détection d'empreinte digitale selon la revendication 29, dans lequel lesdits signaux d'attaque d'image comprennent des rafales de signaux séquentiels appliquées aux plaques respectives desdites plaques d'attaque d'image.

31. Système de détection d'empreinte digitale selon la revendication 30, dans lequel ledit circuit d'excitation inclut des circuits pour coupler des plaques d'attaque d'image non alimentées à un potentiel de référence.

32. Système de détection d'empreinte digitale selon la revendication 30, dans lequel ledit circuit de détection comprend un détecteur synchrone pour délivrer des signaux d'image pulsés.
33. Système de détection d'empreinte digitale selon la revendication 32, dans lequel ledit circuit de capteur comprend, en outre, un convertisseur analogique/numérique pour convertir lesdits signaux d'image pulsés en valeurs numériques, une mémoire et un processeur pour mémoriser les valeurs numériques dans ladite mémoire.
34. Système de détection d'empreinte digitale selon la revendication 33, dans lequel ledit processeur initie une pluralité de balayages de ligne séquentielle desdites plaques d'attaque d'image pour fournir une pluralité de balayages de ligne le long des lignes du doigt en déplacement.
35. Système de détection d'empreinte digitale selon la revendication 29, dans lequel ledit circuit de détection inclut un amplificateur pour recevoir les signaux d'attaque d'image capacitivement couplés, ledit amplificateur présentant un gain qui est une fonction inverse de l'amplitude des signaux d'attaque d'image capacitivement couplés.
36. Système de détection d'empreinte digitale selon la revendication 20, dans lequel ledit capteur de vitesse comprend :
- deux ou plus détecteurs de doigt espacés le long d'une direction de déplacement du doigt, chacun desdits détecteurs de doigt incluant au moins une plaque d'attaque de vitesse et au moins une plaque de capture de vitesse, dans lequel une extrémité du doigt passant sur chacun desdits détecteurs de doigt produit un changement de la capacité entre les plaques d'attaque de vitesse respectives et les plaques de capture de vitesse.
37. Système de détection d'empreinte digitale selon la revendication 36, dans lequel la plaque d'attaque de vitesse et la plaque de capture de vitesse de chacun desdits détecteurs de doigt sont disposées généralement orthogonalement à la direction de déplacement du doigt.
38. Système de détection d'empreinte digitale selon la revendication 36, dans lequel les plaques de capture de vitesse desdits détecteurs de doigt sont connectées en commun.
39. Système de détection d'empreinte digitale selon la revendication 36, dans lequel chacun desdits détecteurs de doigt inclut des première et seconde plaques de capture de vitesse disposées sur les côtés opposés de la plaque d'attaque de vitesse pour former un capteur capacitif différentiel.
40. Système de détection d'empreinte digitale selon la revendication 39, dans lequel les plaques d'attaque de vitesse desdits détecteurs de doigt sont connectées en commun.
41. Système de détection d'empreinte digitale selon la revendication 36, dans lequel les plaques d'attaque de vitesse et les plaques de capture de vitesse desdits détecteurs de doigt sont incurvées pour correspondre sensiblement à l'incurvation d'un bout de doigt typique.
42. Système de détection d'empreinte digitale selon la revendication 36, comprenant, en outre, un substrat, dans lequel lesdites plaques d'attaque de vitesse et lesdites plaques de capture de vitesse comprennent des pistes conductrices sur ledit substrat.
43. Système de détection d'empreinte digitale selon la revendication 36, comprenant, en outre, un substrat souple, dans lequel lesdites plaques d'attaque de vitesse et lesdites plaques de capture de vitesse comprennent des pistes conductrices sur ledit substrat souple.
44. Système de détection d'empreinte digitale selon la revendication 36, dans lequel ledit circuit capteur comprend :
- un circuit d'excitation pour alimenter les plaques d'attaque de vitesse desdits détecteurs de doigt avec lesdits signaux d'attaque de vitesse, et
un circuit de détection pour détecter les signaux d'attaque de vitesse couplés capacitivement depuis la plaque d'attaque de vitesse à la plaque de capture de vitesse de chacun desdits détecteurs de doigt pour délivrer lesdits signaux de vitesse.
45. Système de détection d'empreinte digitale selon la revendication 44, dans lequel lesdits signaux d'attaque de vitesse comprennent des rafales de signaux.
46. Système de détection d'empreinte digitale selon la revendication 45, dans lequel ledit circuit de détection comprend un détecteur synchrone.
47. Système de détection d'empreinte digitale selon la revendication 44, dans lequel ledit circuit de capteur comprend, en outre, un circuit de traitement pour détecter un retard de temps entre lesdits signaux

de vitesse provenant desdits détecteurs de doigt, dans lequel ledit retard de temps entre lesdits signaux de vitesse est représentatif de la vitesse du doigt.

48. Système de détection d'empreinte digitale selon la revendication 20, comprenant, en outre, un substrat, dans lequel ledit capteur d'image et ledit capteur de vitesse sont fabriqués sur ledit substrat.

49. Système de détection d'empreinte digitale selon la revendication 48, dans lequel ledit substrat comprend un substrat souple.

50. Système de détection d'empreinte digitale selon la revendication 48, dans lequel ledit circuit du capteur est monté sur ledit substrat.

51. Procédé de détection d'empreinte digitale, comprenant les étapes consistant à :

détecter capacitivement les crêtes de motif et les vallées de motif d'une empreinte digitale sur un doigt animé d'un mouvement de balayage (120) avec une rangée de capteurs capacitifs et délivrer des signaux d'image représentatifs d'une ligne de l'empreinte digitale, la rangée des capteurs capacitifs comprenant une plaque de capture d'image (116) disposée généralement orthogonalement à la direction du déplacement du doigt et une pluralité de plaques d'attaque d'image (114) en relation espacée avec la plaque de capture d'image pour définir une pluralité d'espaces de capteur (118) entre les plaques d'attaque d'image (114) respectives et la plaque de capture d'image (116), dans lequel les crêtes de motif et les vallées de motif de l'empreinte digitale passant sur lesdits espaces de capteur (118) produisent un changement de capacité entre les plaques d'attaque d'image (114) respectives et ladite plaque de capture d'image (116) ; et acquérir à partir de la rangée des capteurs capacitifs des signaux d'image représentatifs des multiples lignes de l'empreinte digitale pour délivrer une image de l'empreinte digitale.

52. Procédé de détection d'empreinte digitale selon la revendication 51, comprenant les étapes supplémentaires consistant à :

détecter une vitesse du doigt à mesure qu'il est balayé à travers la rangée des capteurs capacitifs et délivrer des signaux de vitesse ; et coordonner les signaux d'image et les signaux de vitesse pour délivrer l'image de l'empreinte digitale.

53. Appareil de détection d'image selon la revendication 1, dans lequel ladite plaque de capture d'image et ladite pluralité de plaques d'attaque d'image sont sensiblement coplanaires.

54. Système de détection d'empreinte digitale selon la revendication 20, dans lequel ladite plaque de capture d'image et ladite pluralité de plaques d'attaque d'image sont sensiblement coplanaires.

55. Système de détection d'empreinte digitale selon la revendication 36, dans lequel la plaque d'attaque de vitesse et la plaque de capture de vitesse de chacun desdits détecteurs de doigt sont sensiblement coplanaires.

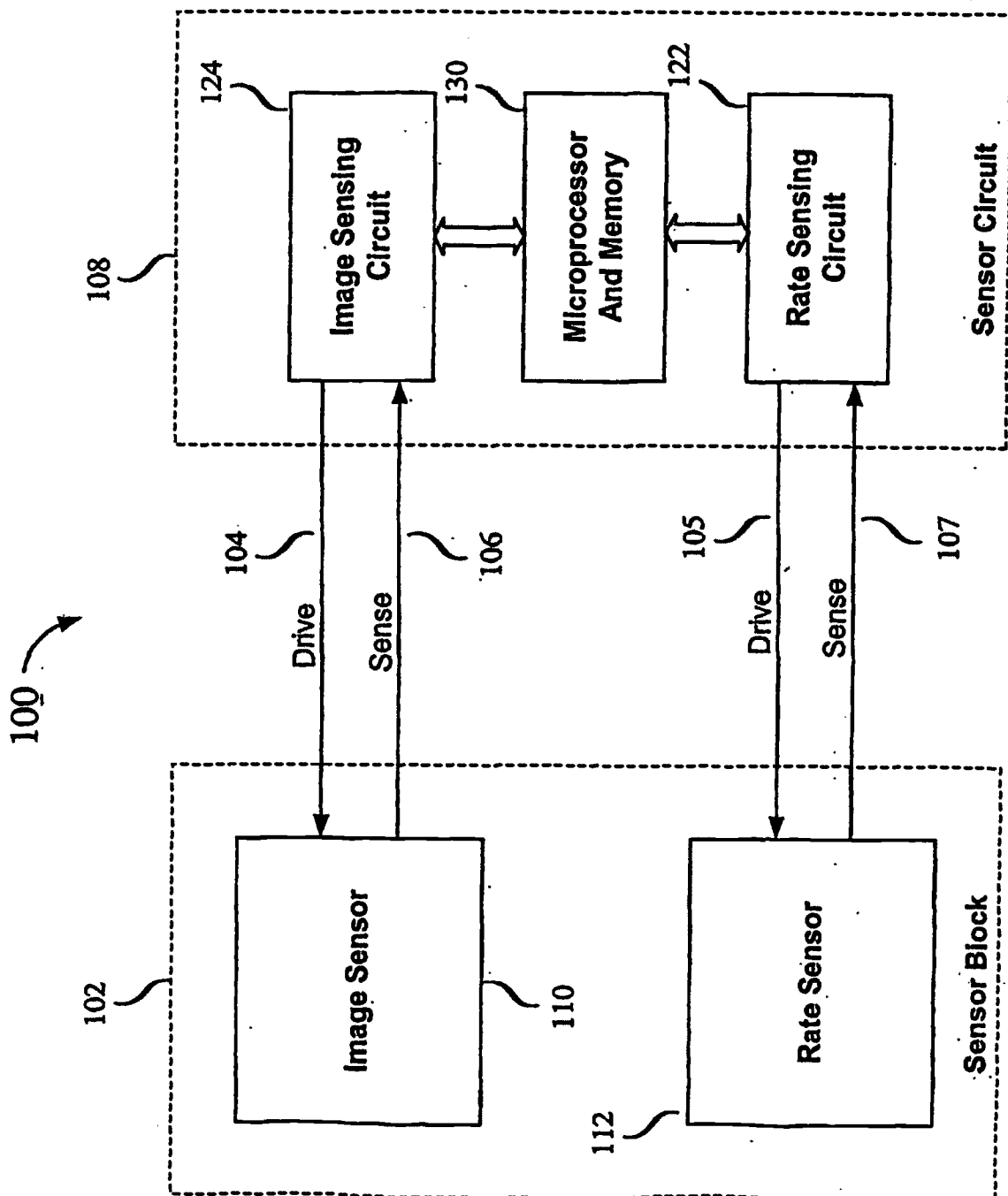
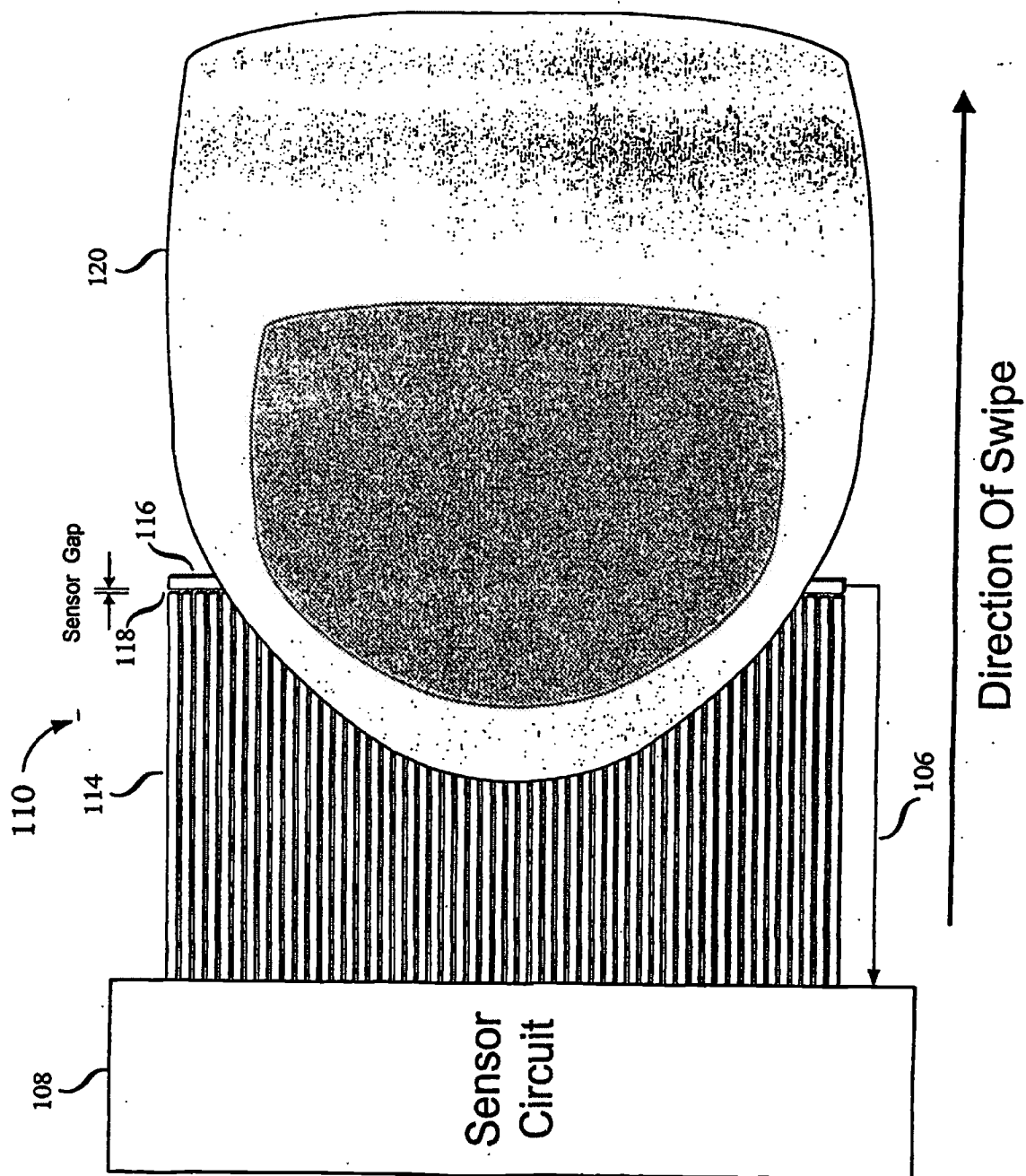
Figure 1A

Figure 1B



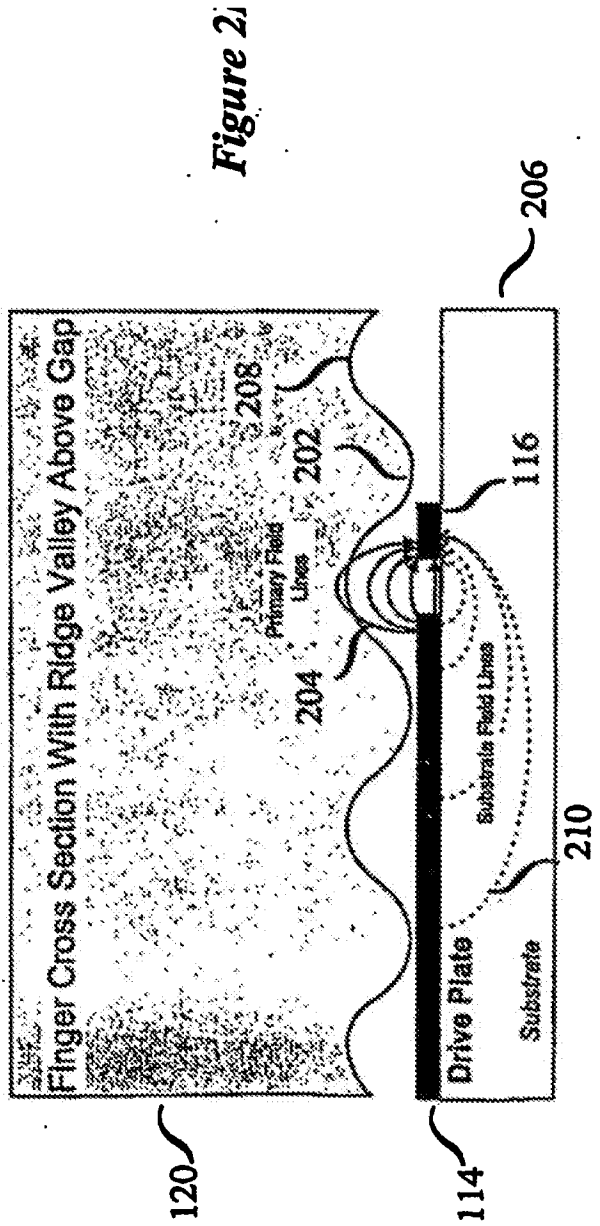
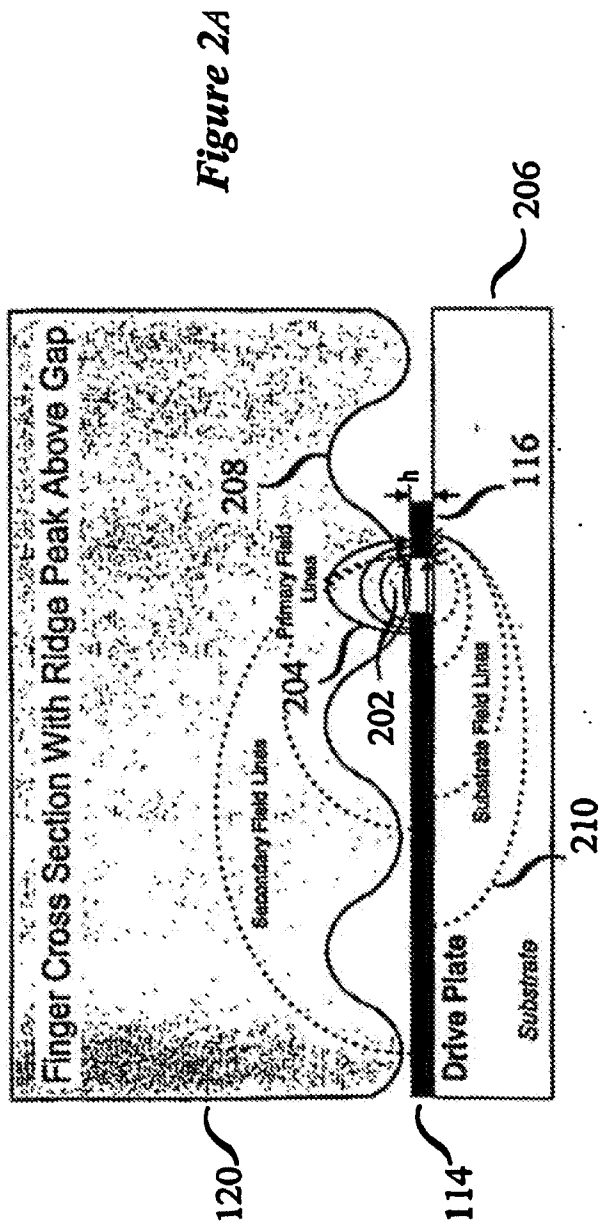


Figure 3

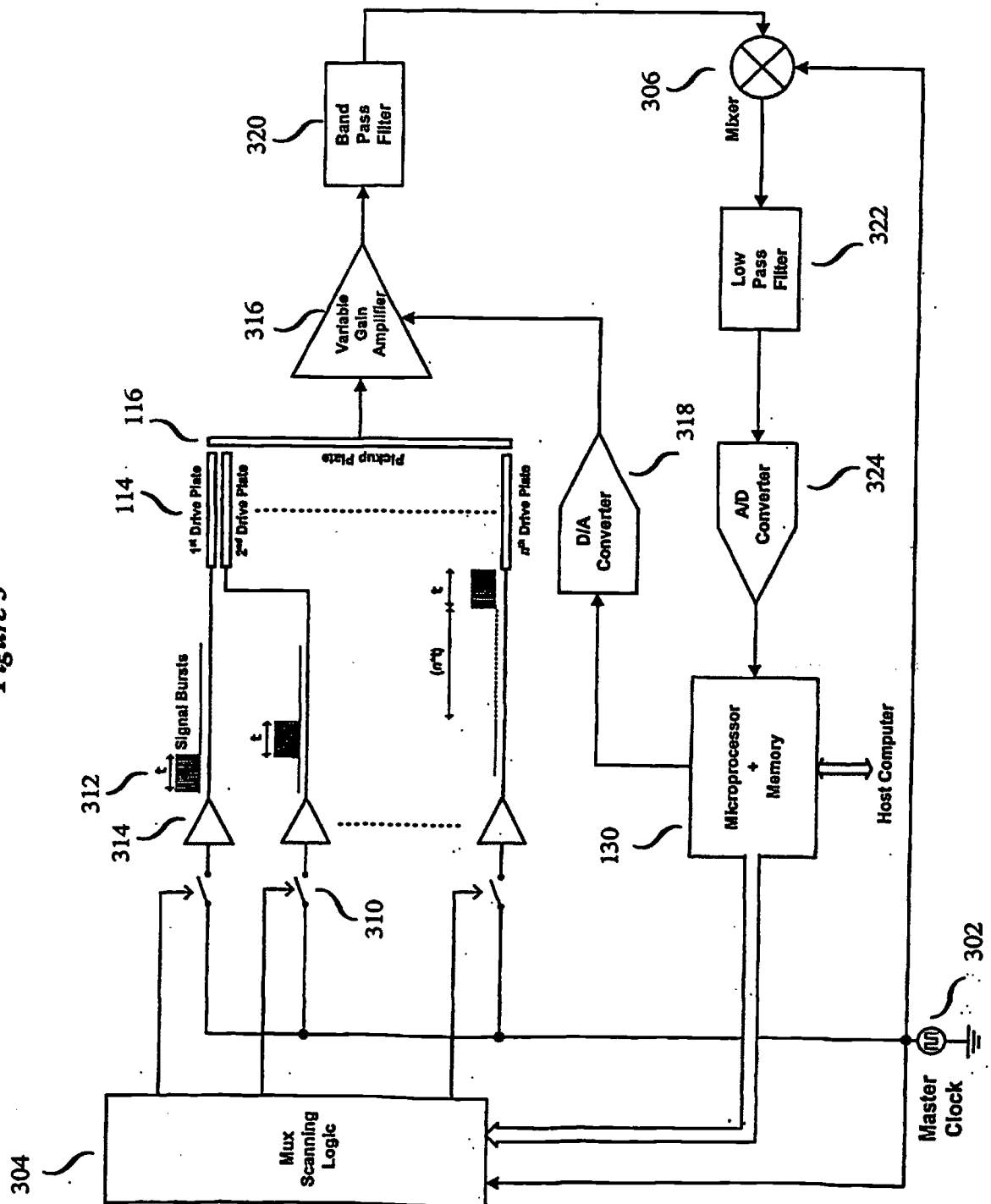


Figure 4

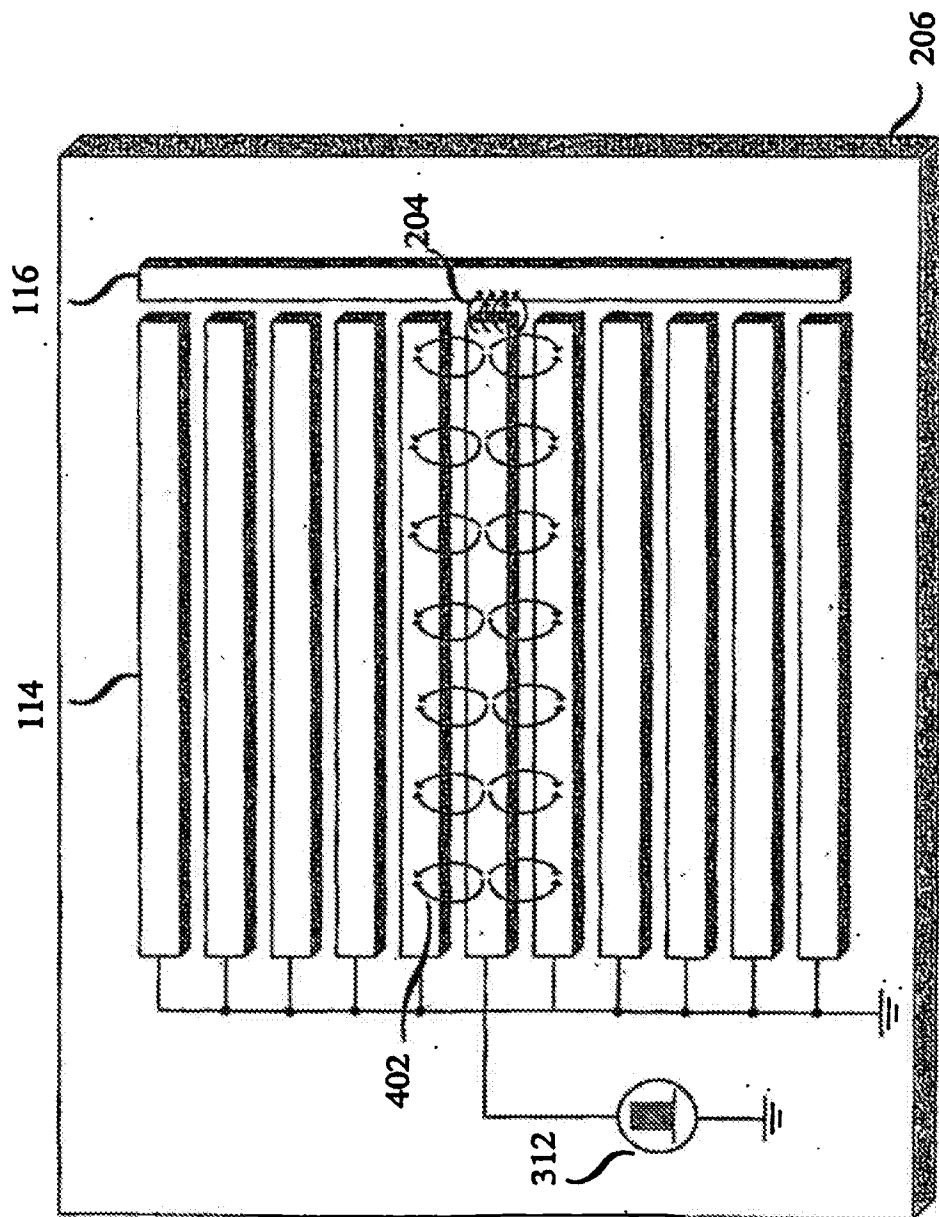


Figure 5

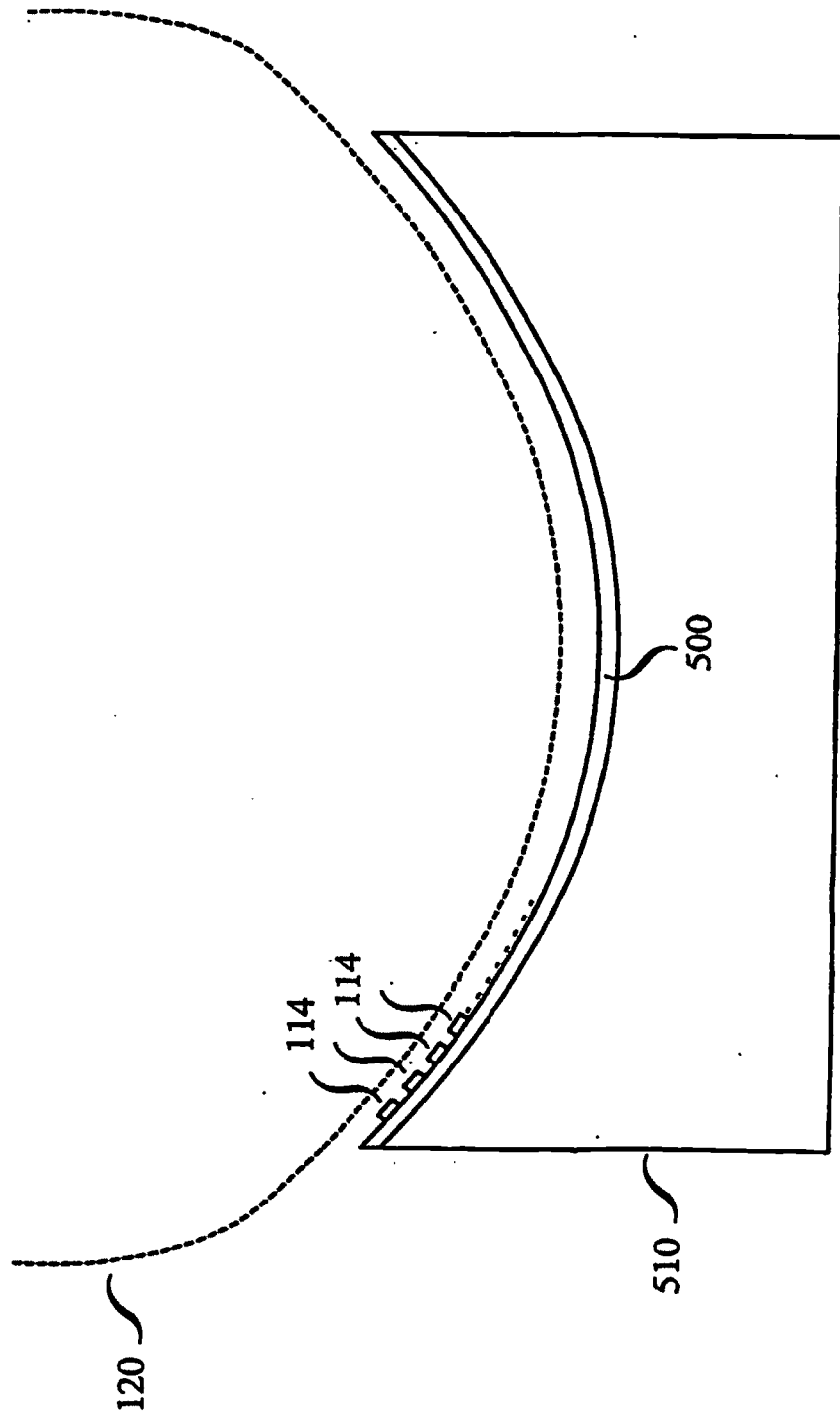


Figure 6

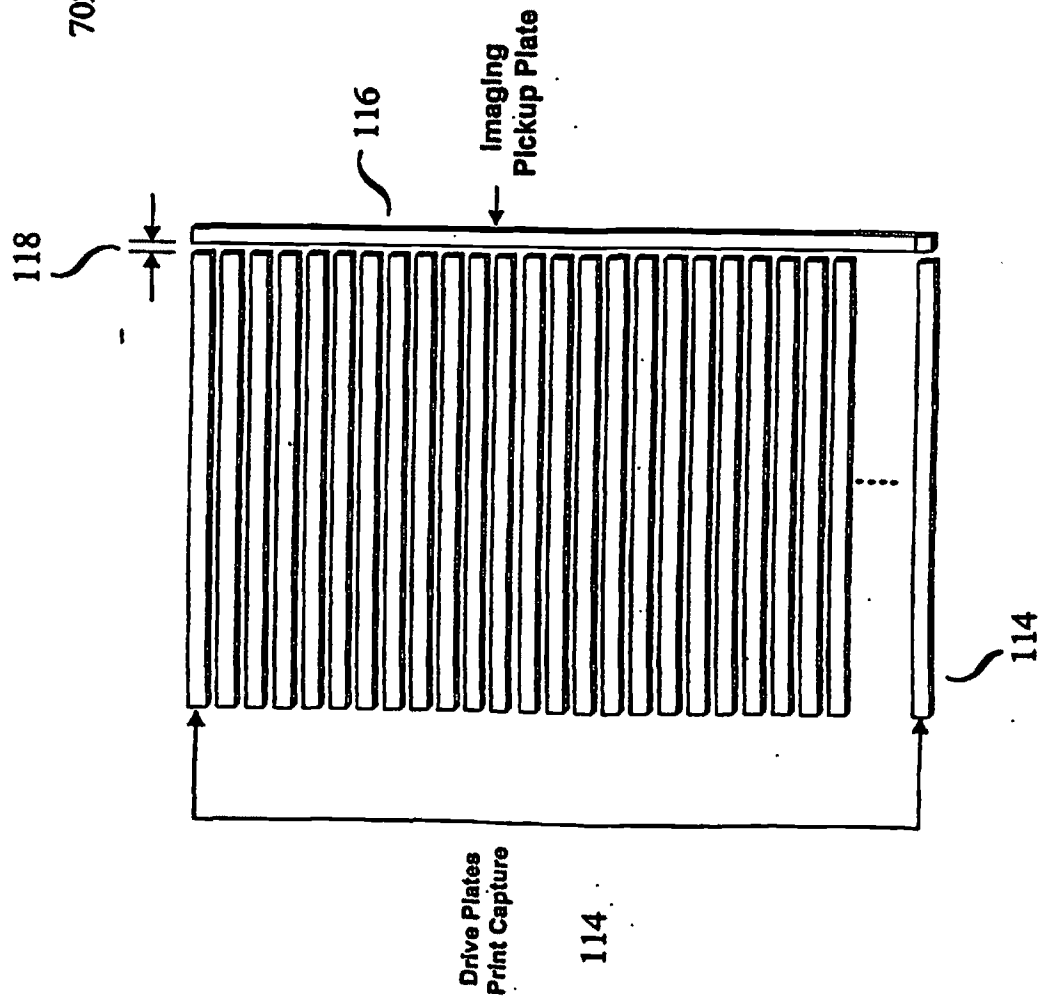


Figure 7

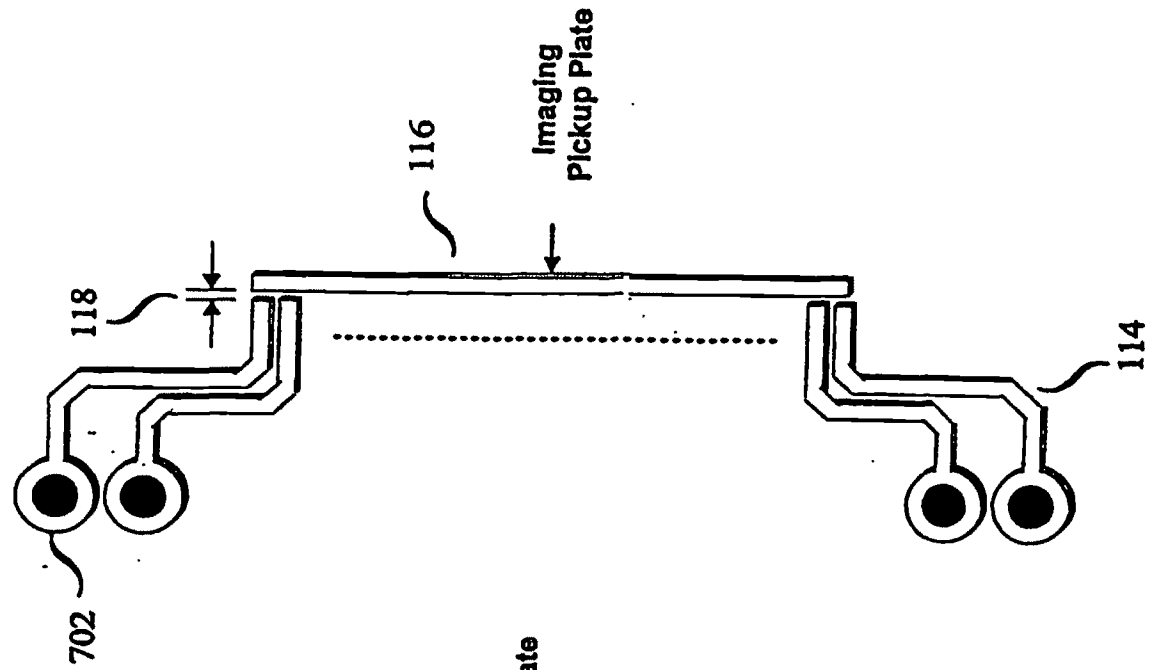


Figure 8

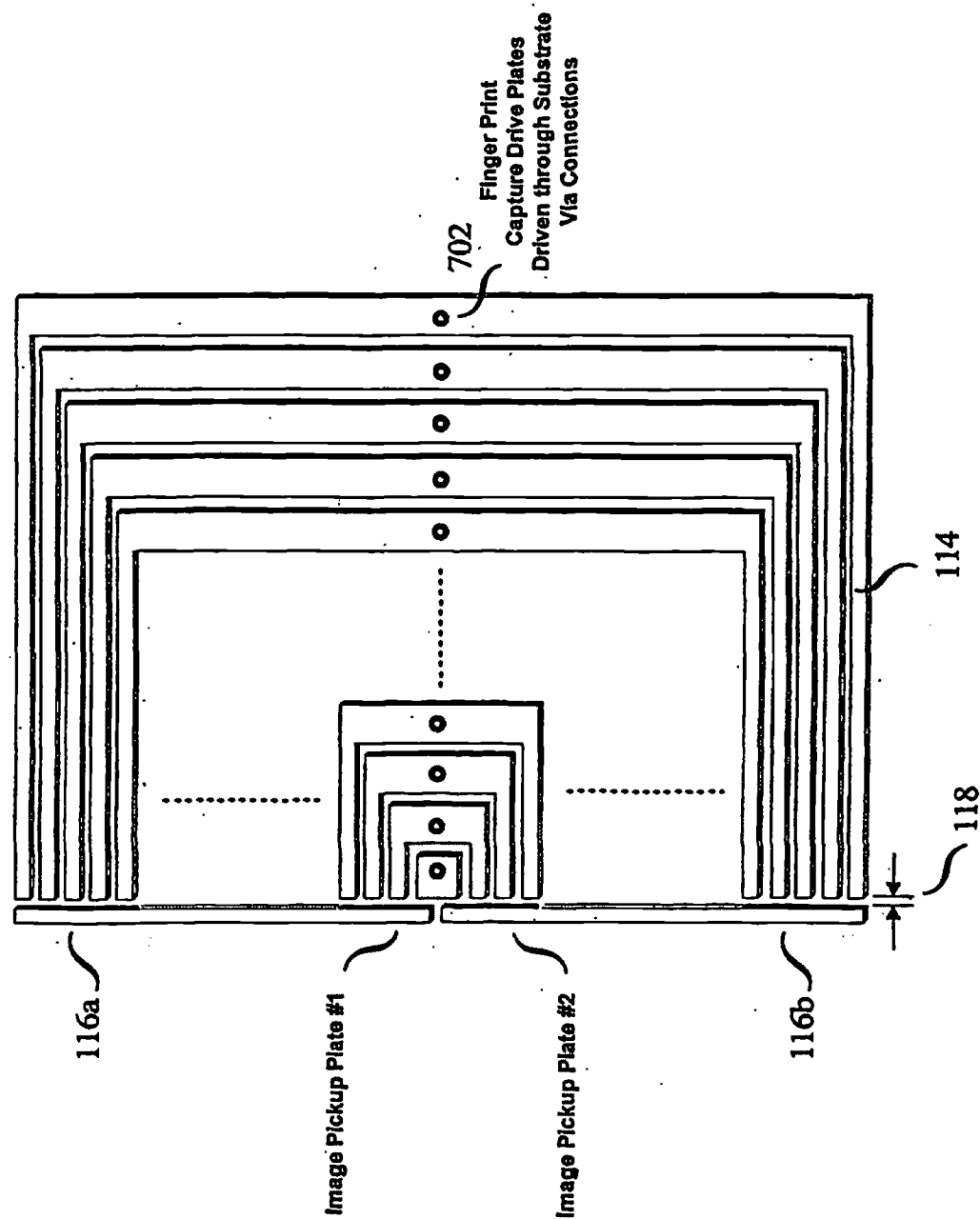


Figure 9

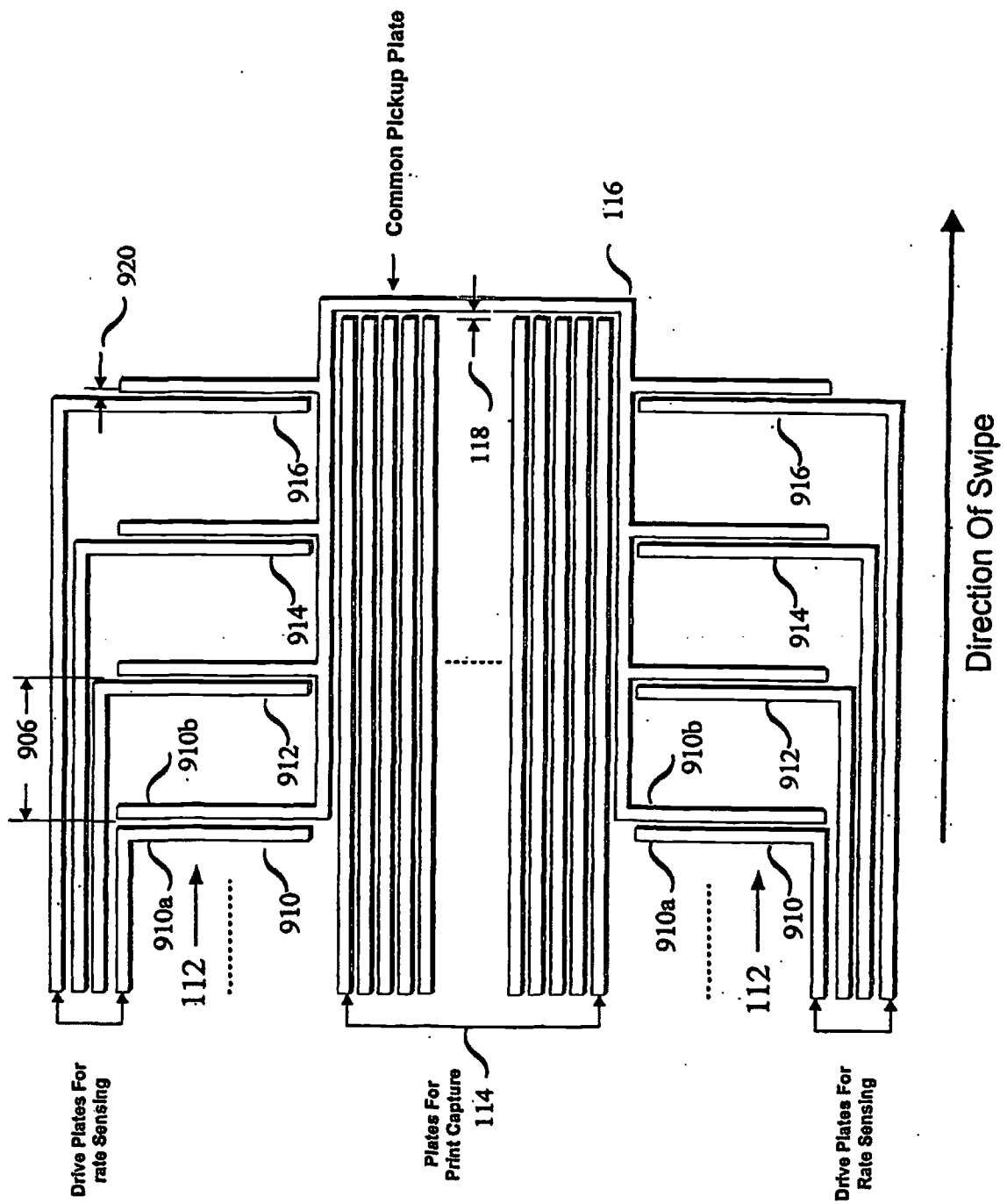


Figure 10

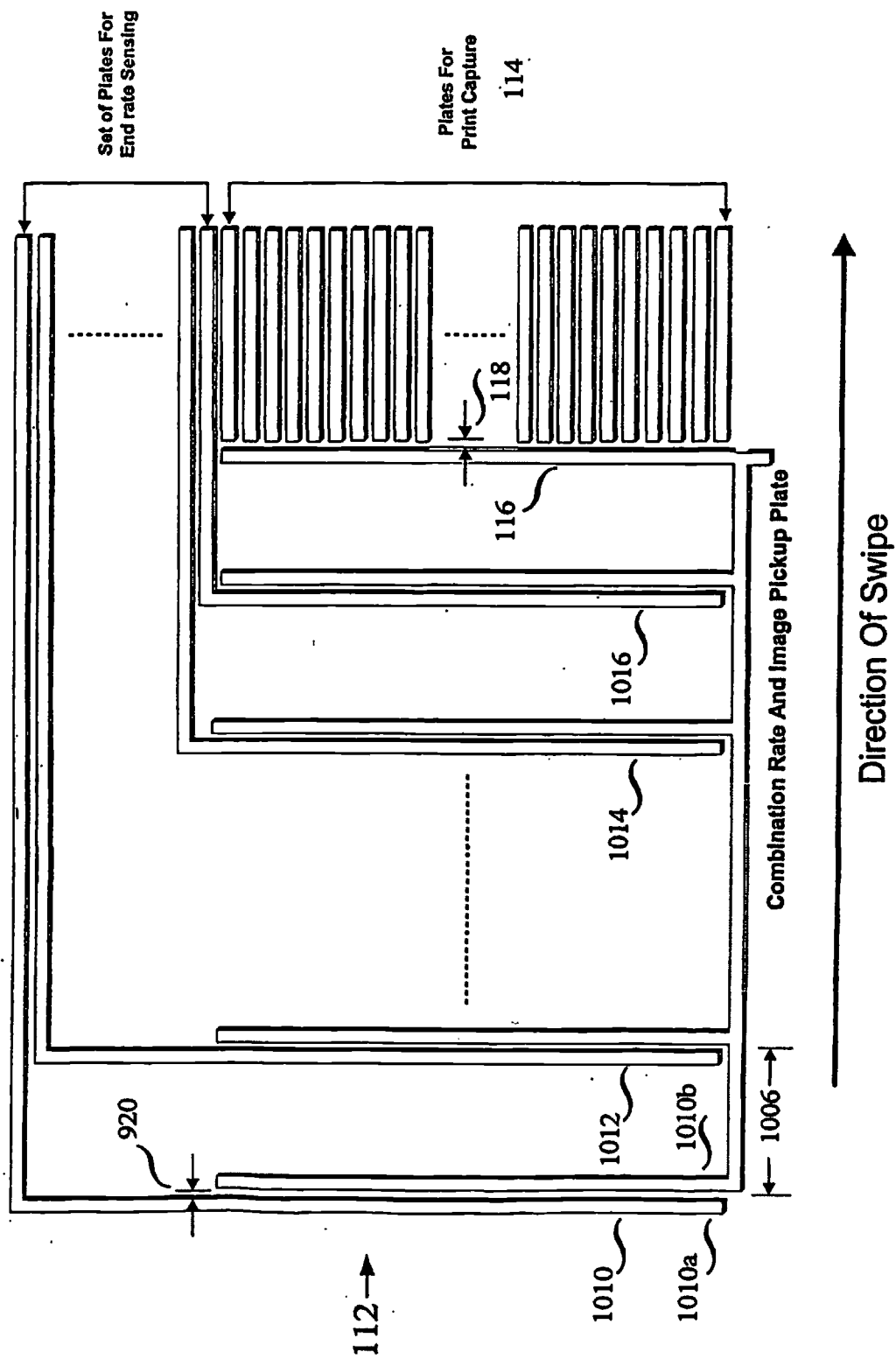


Figure 11

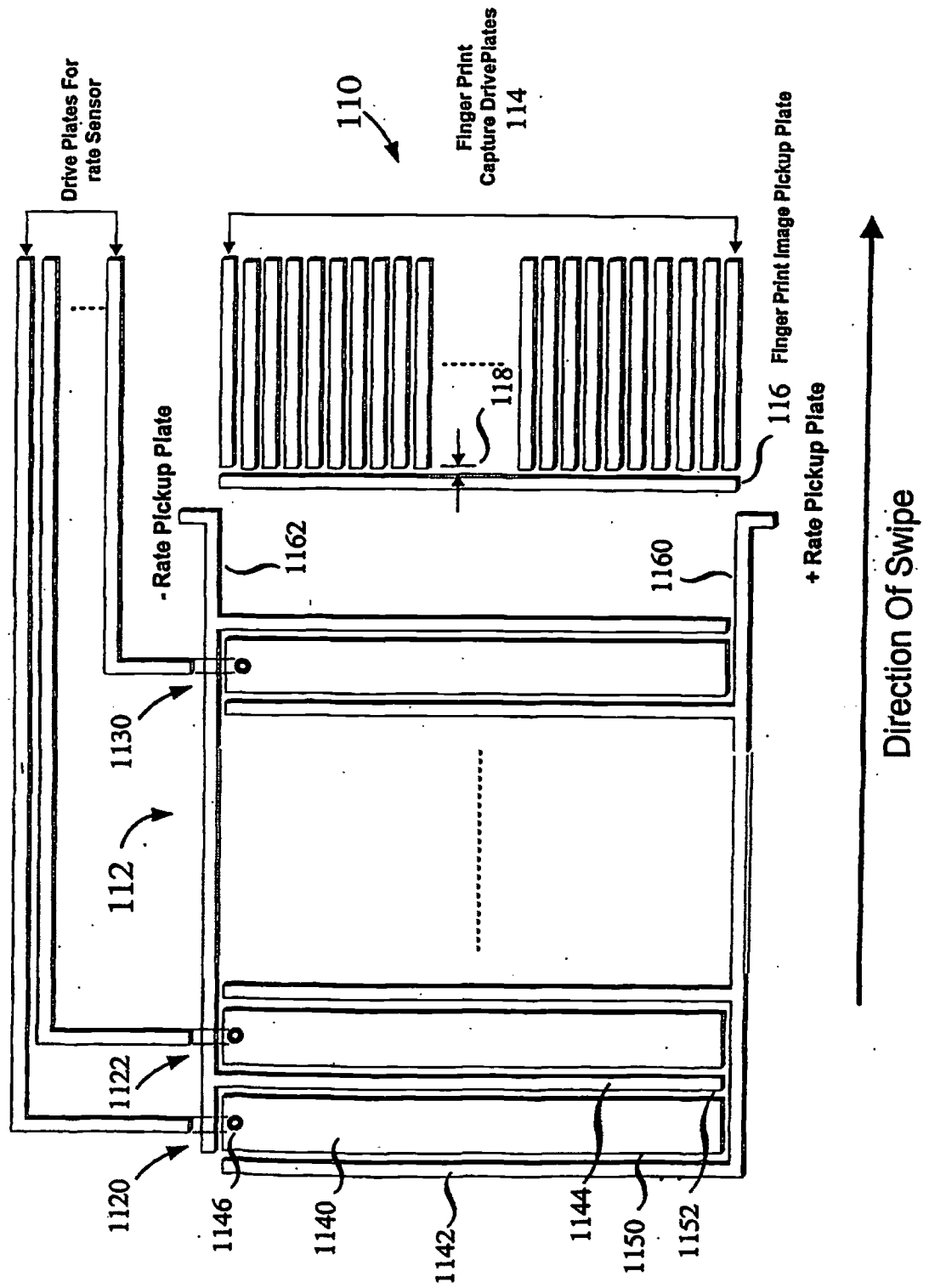


Figure 12

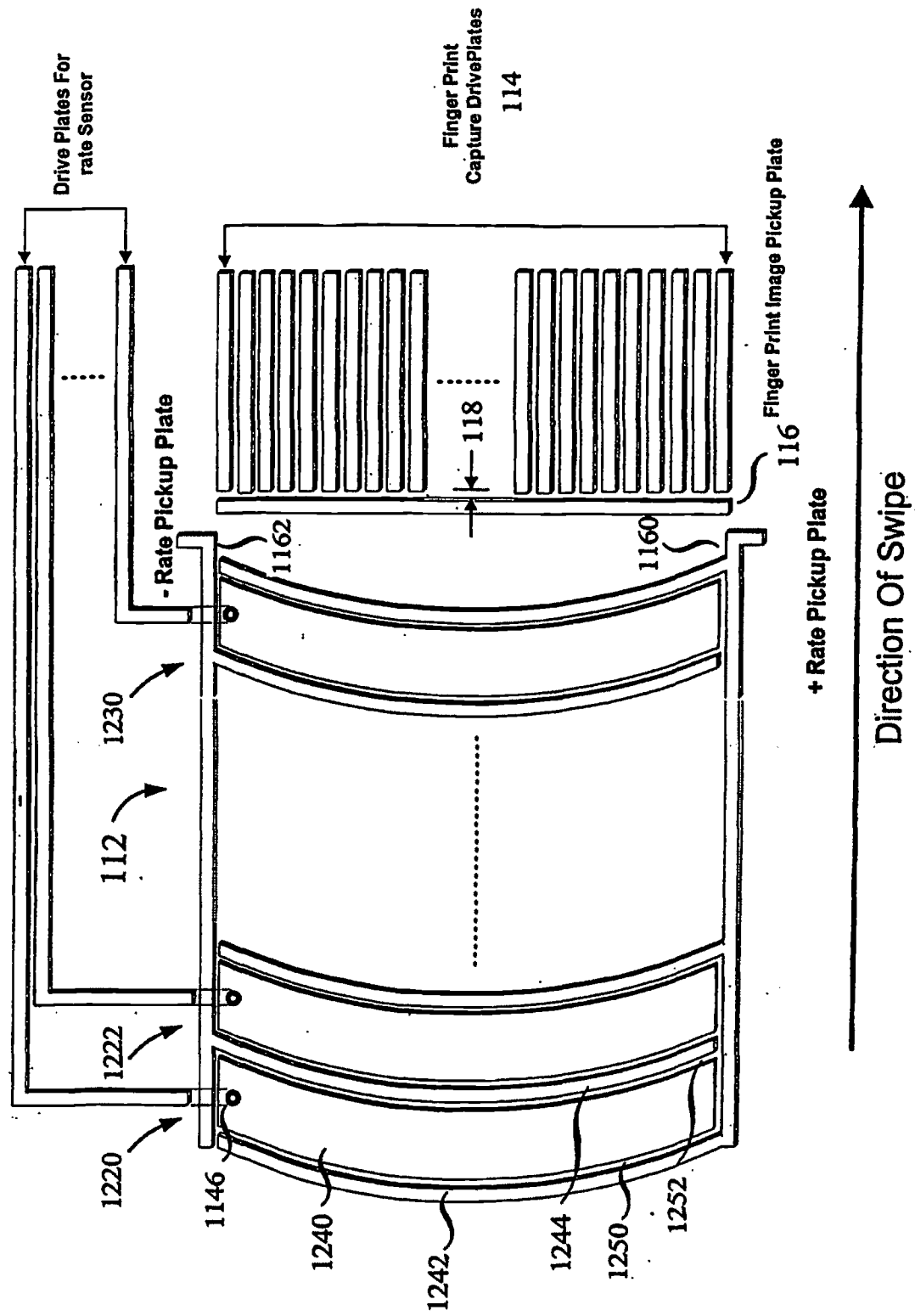


Figure 13

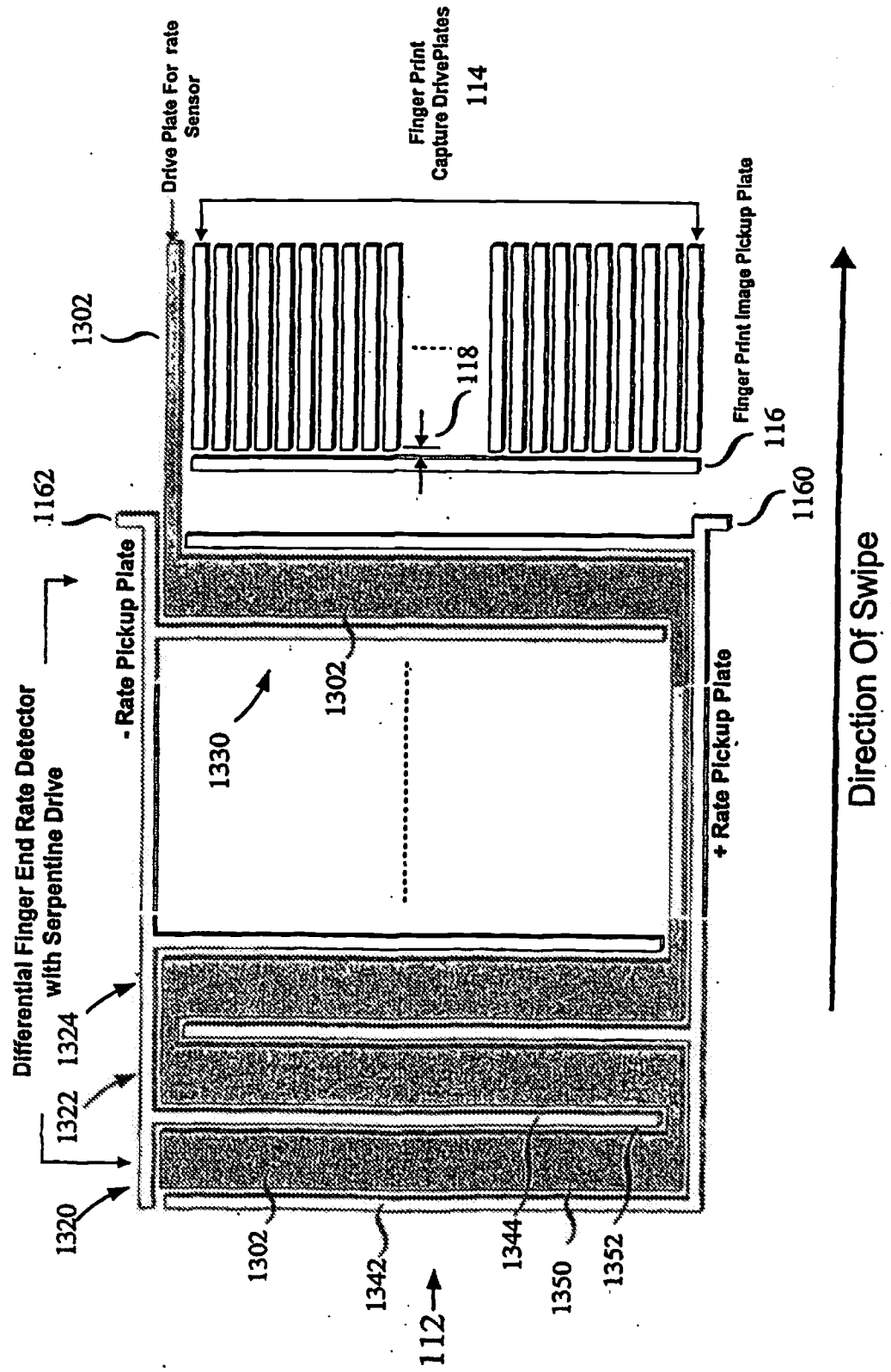


Figure 14

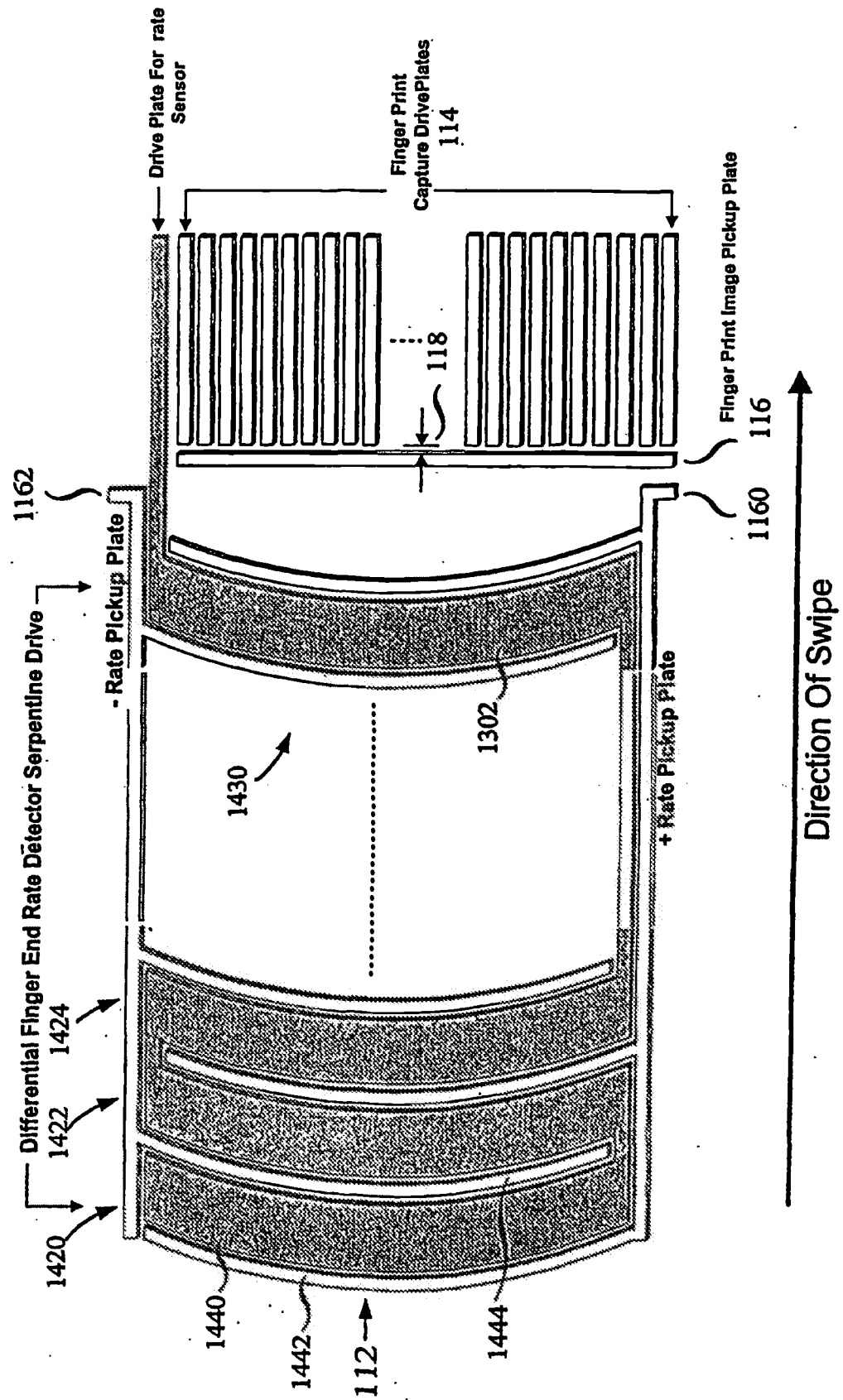


Figure 15

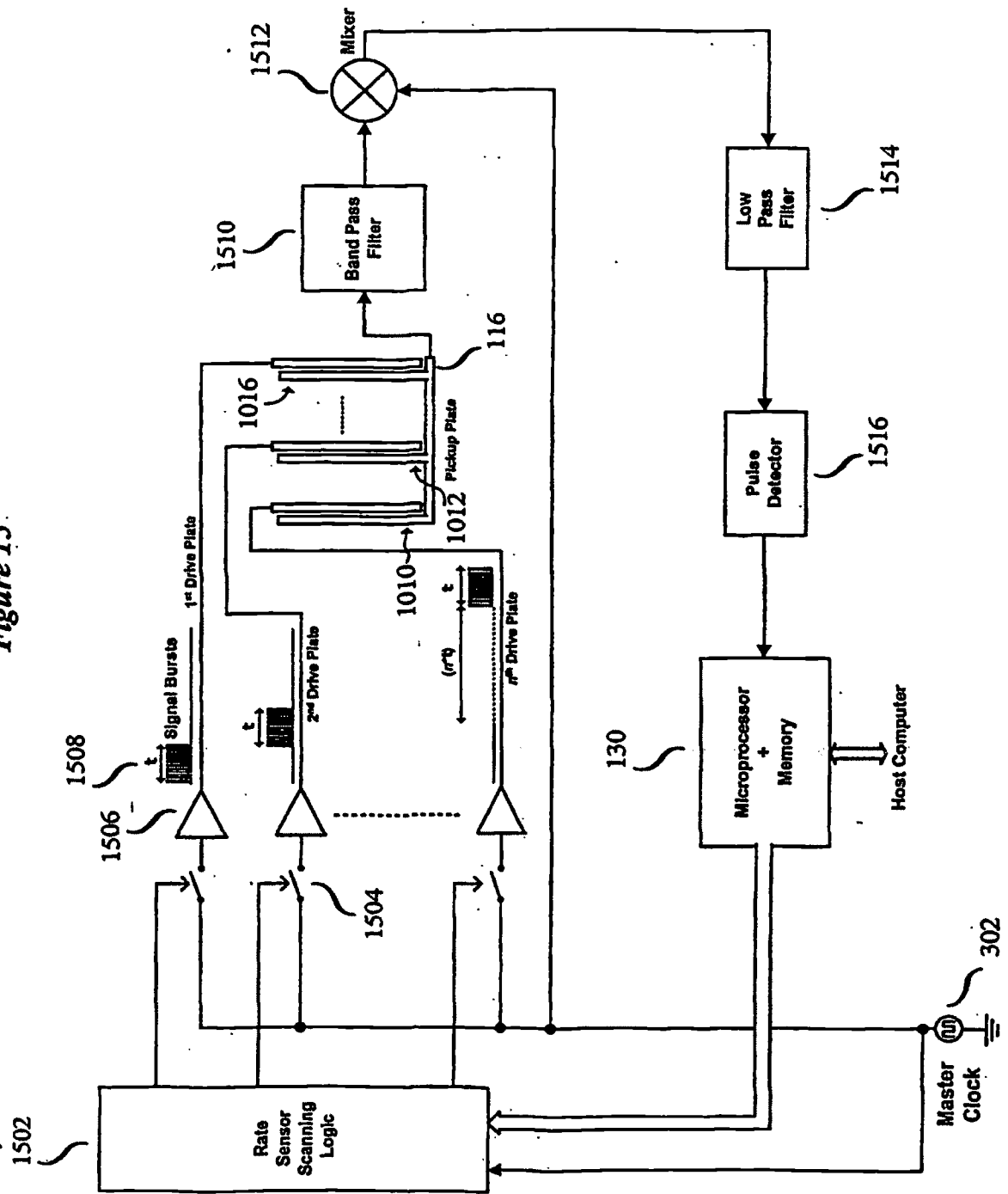


Figure 16

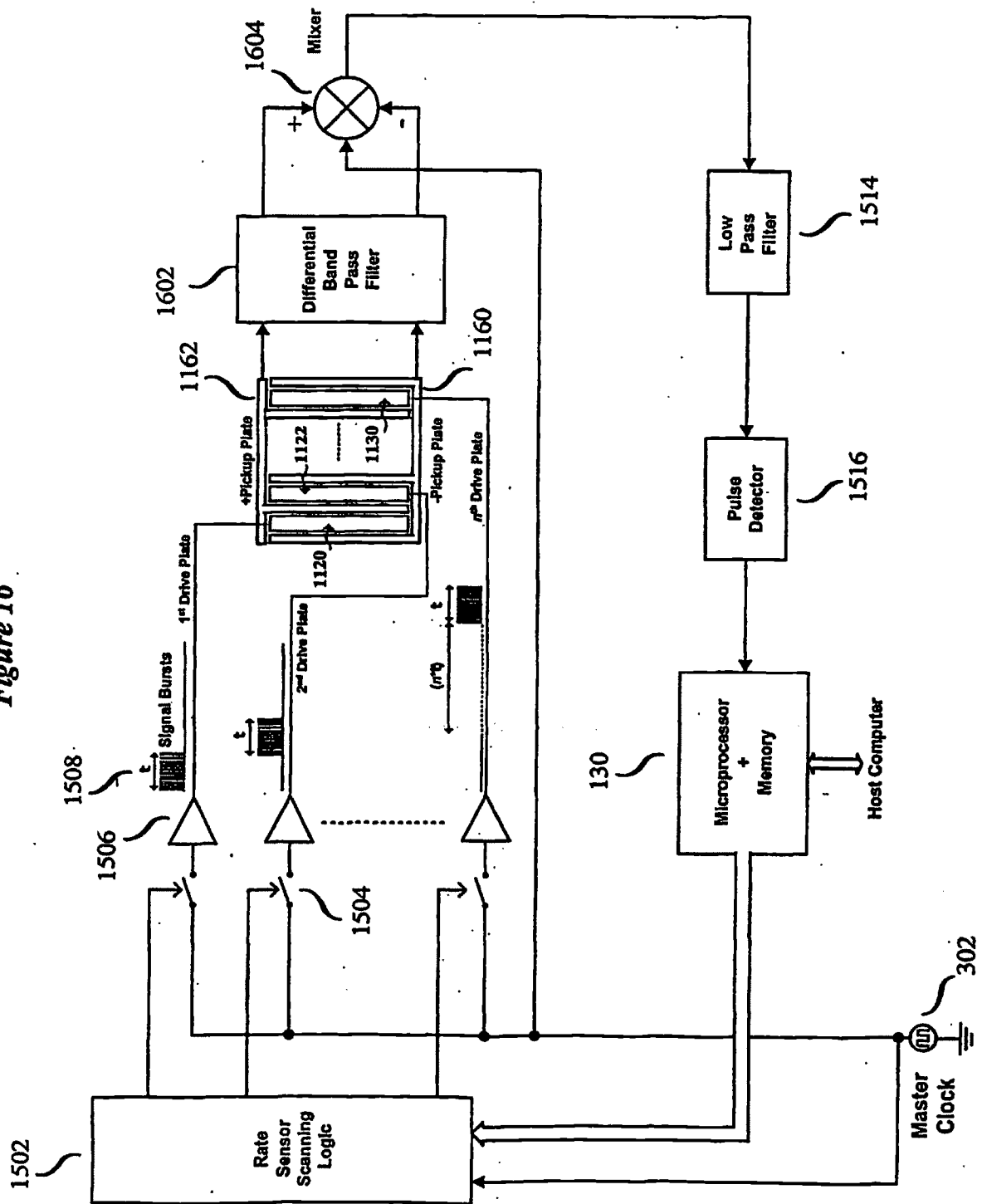


Figure 17

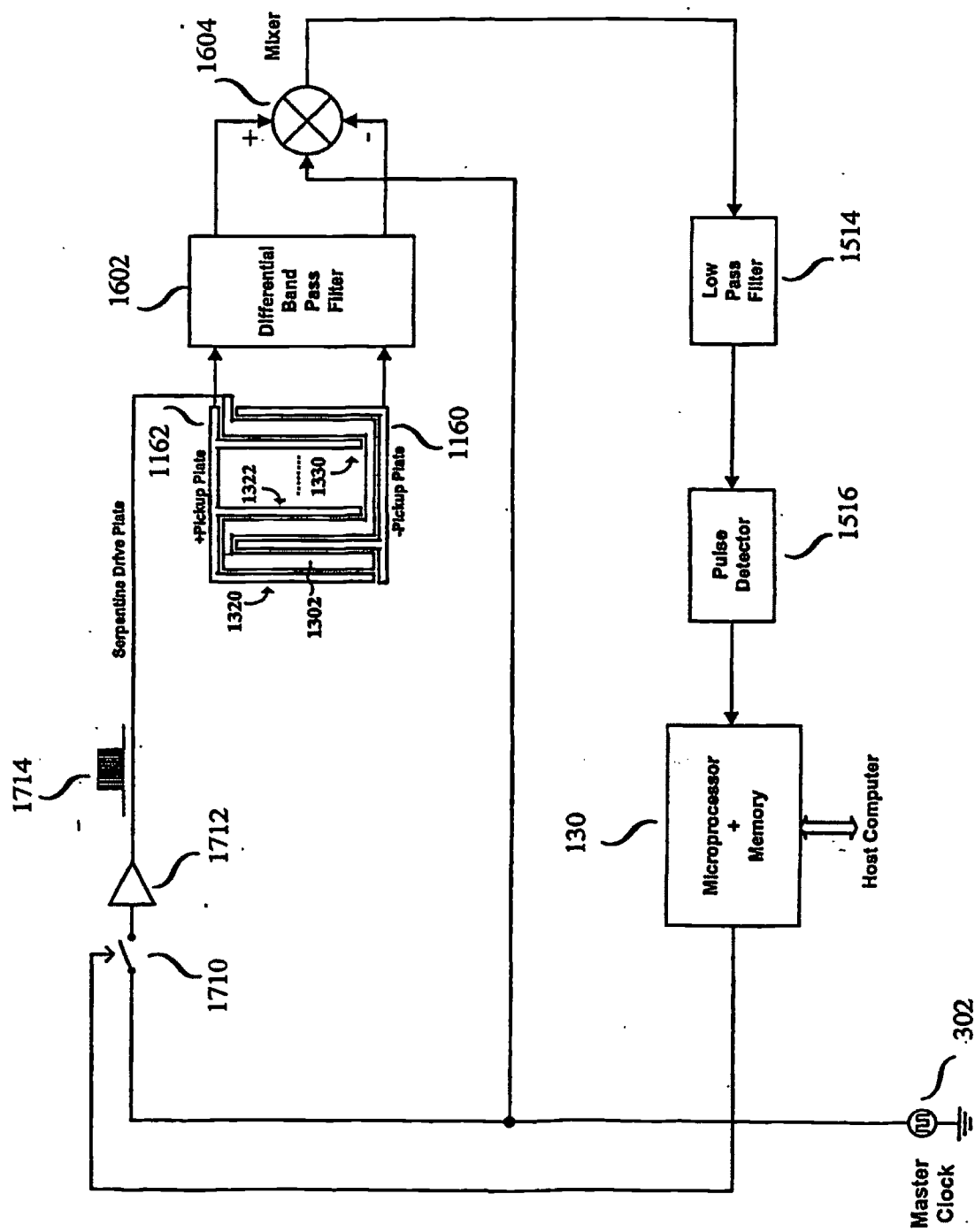


Figure 18

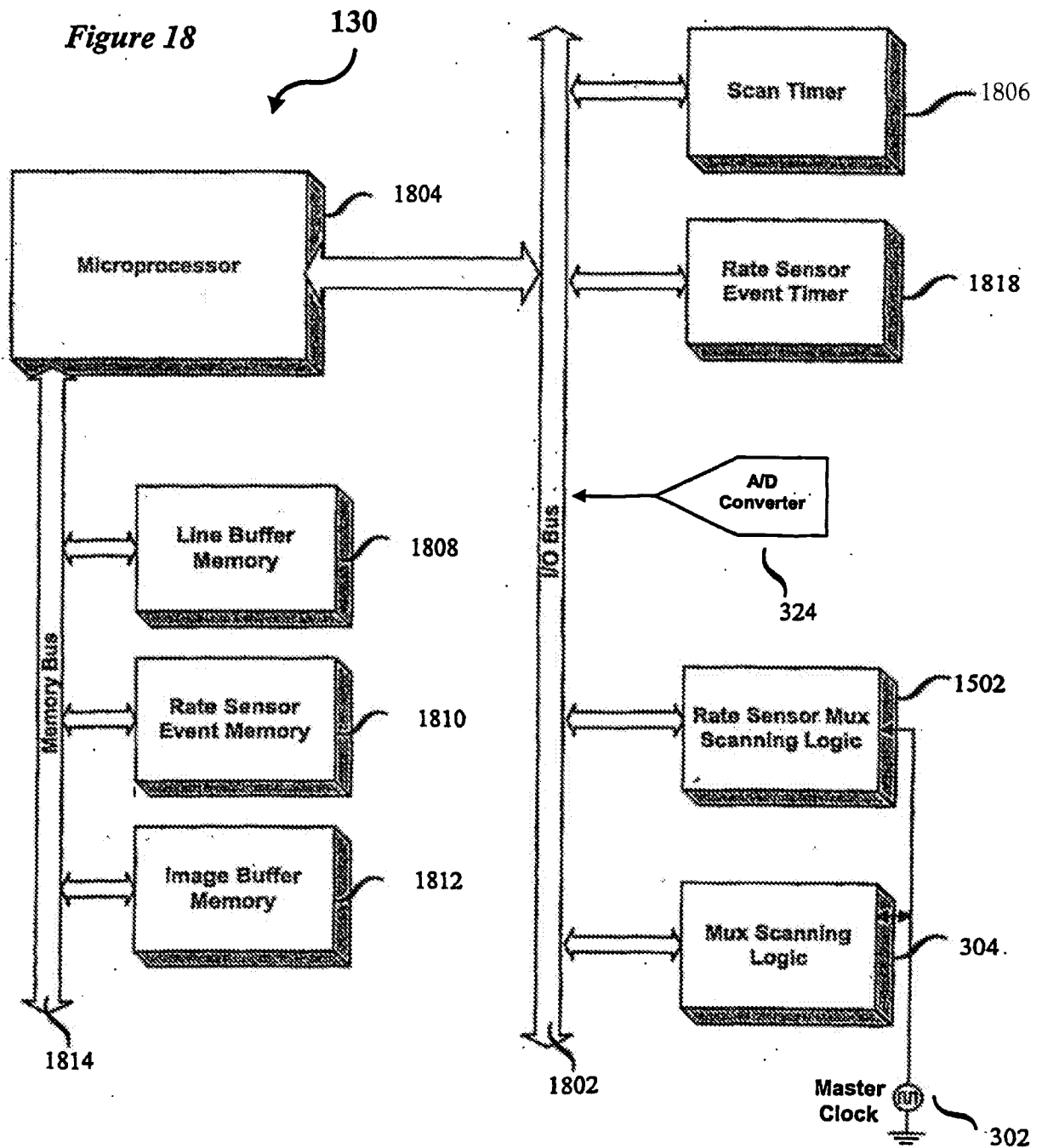


Figure 19

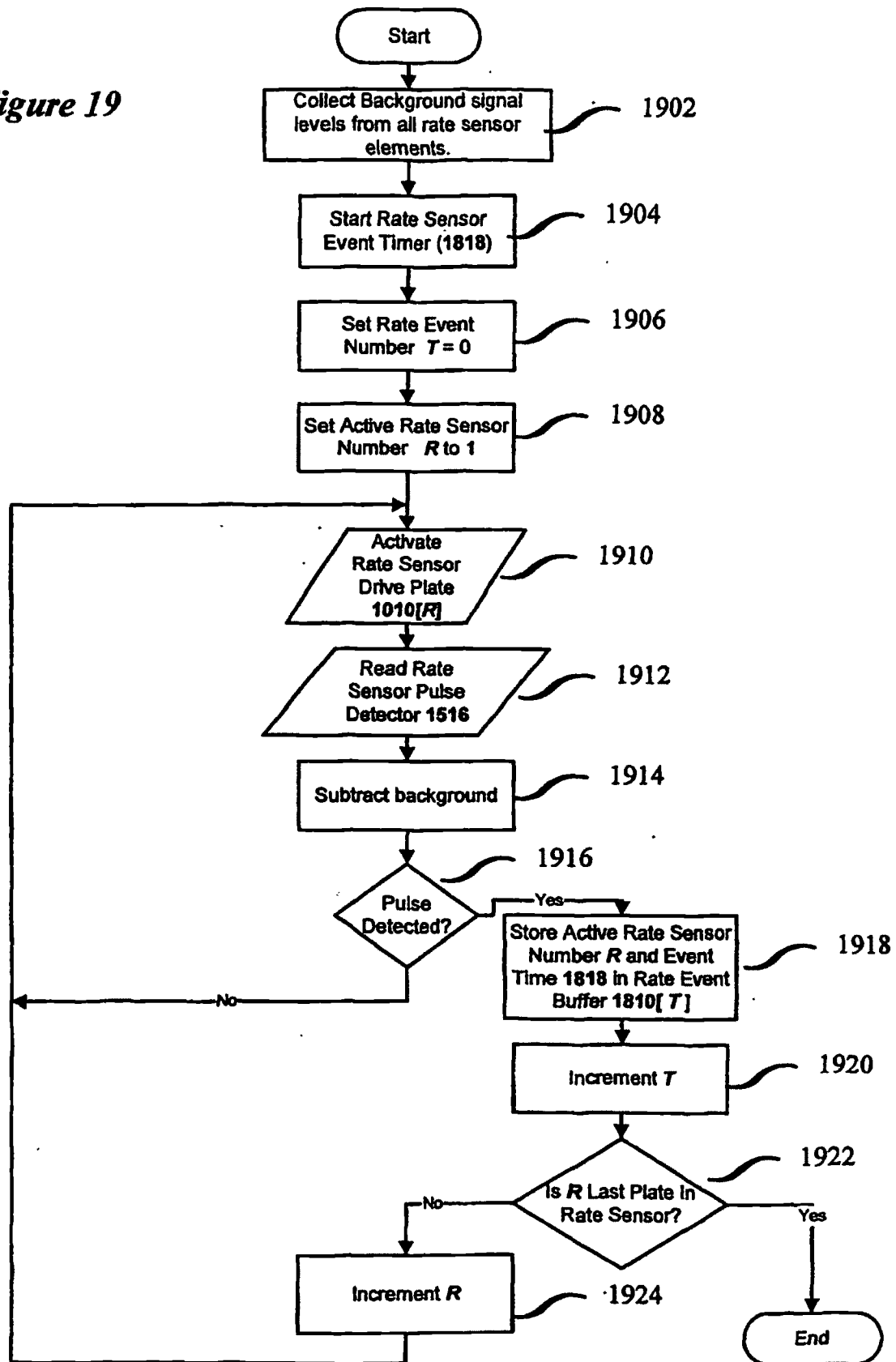


Figure 20

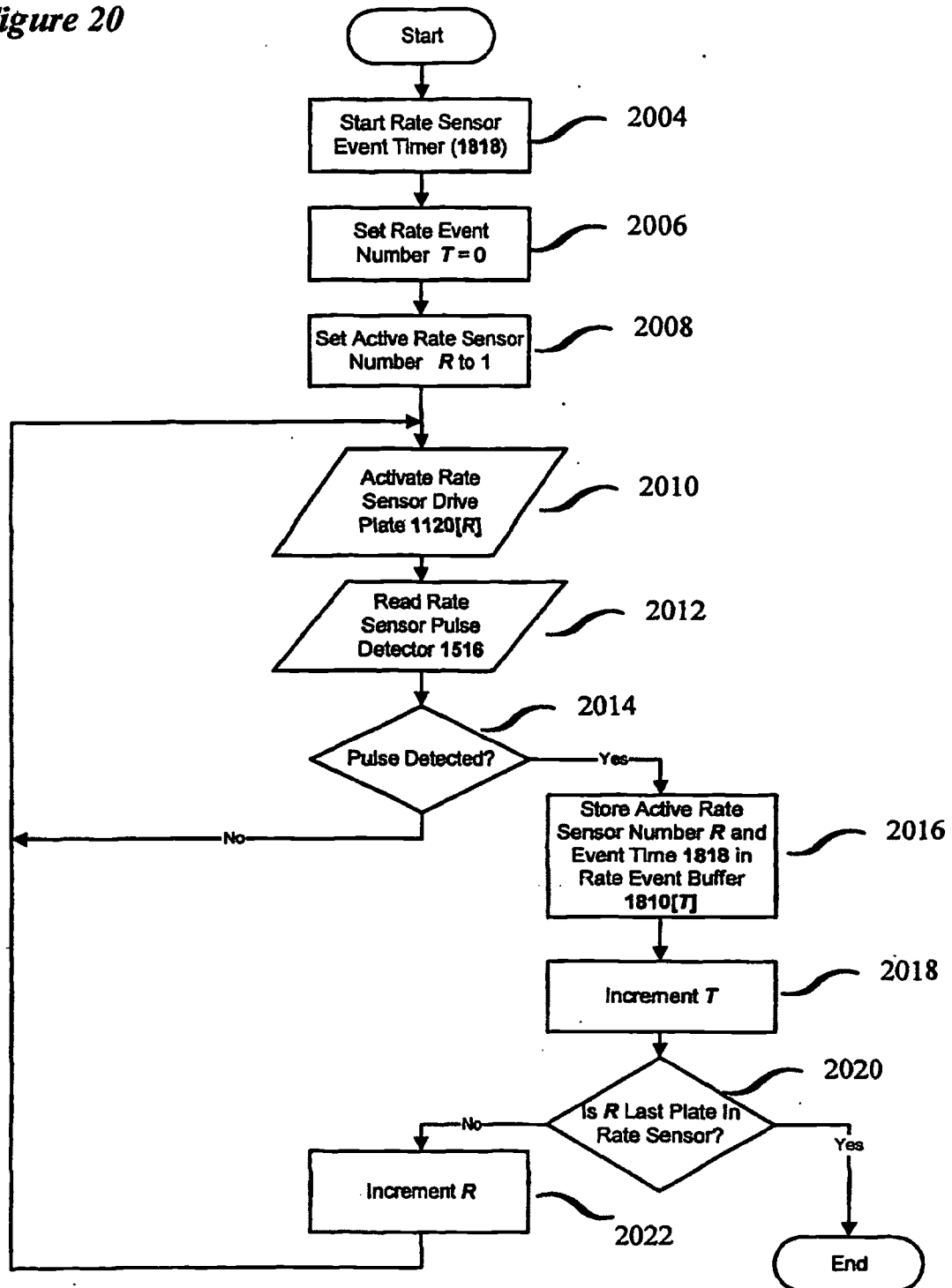


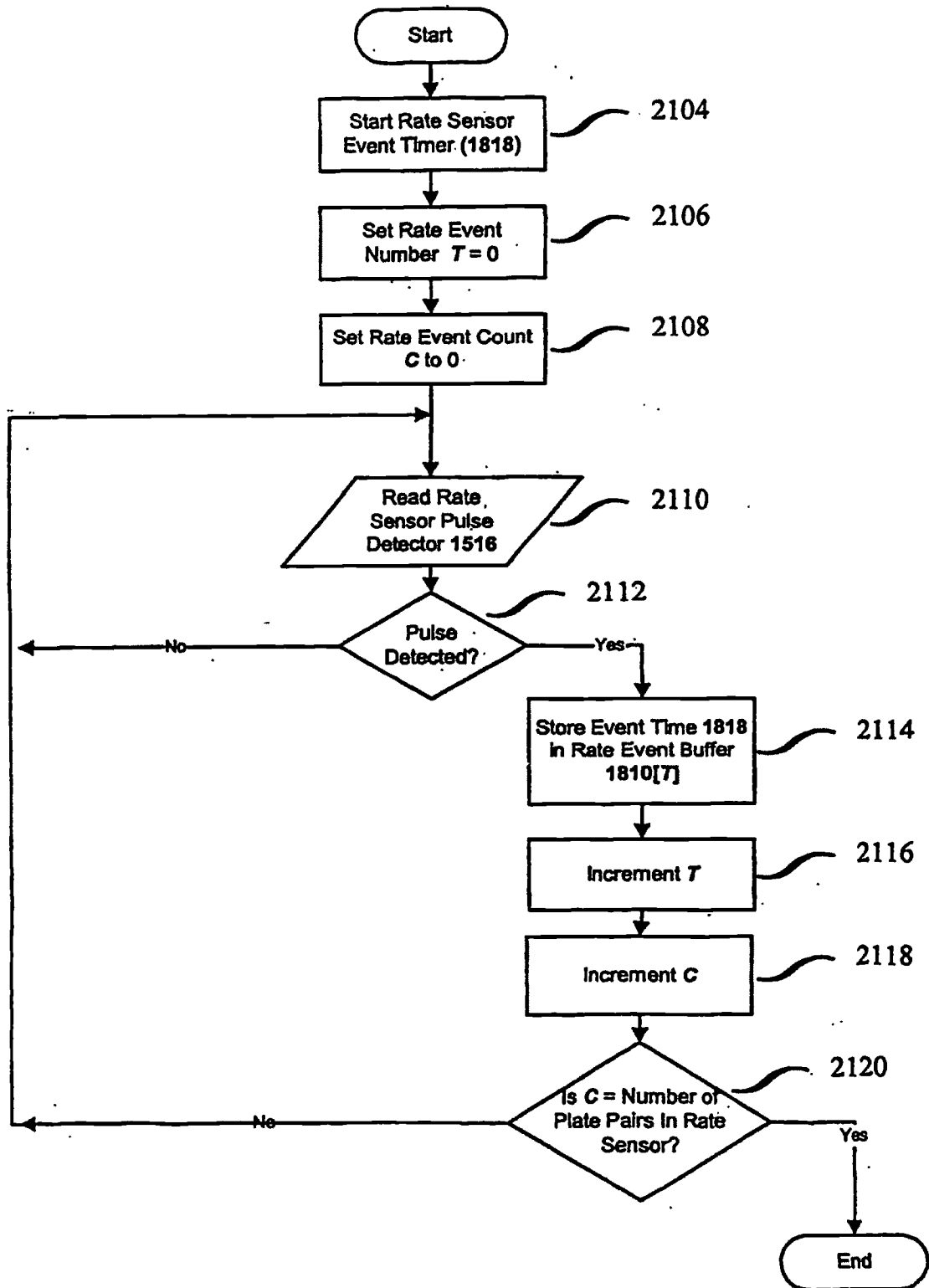
Figure 21

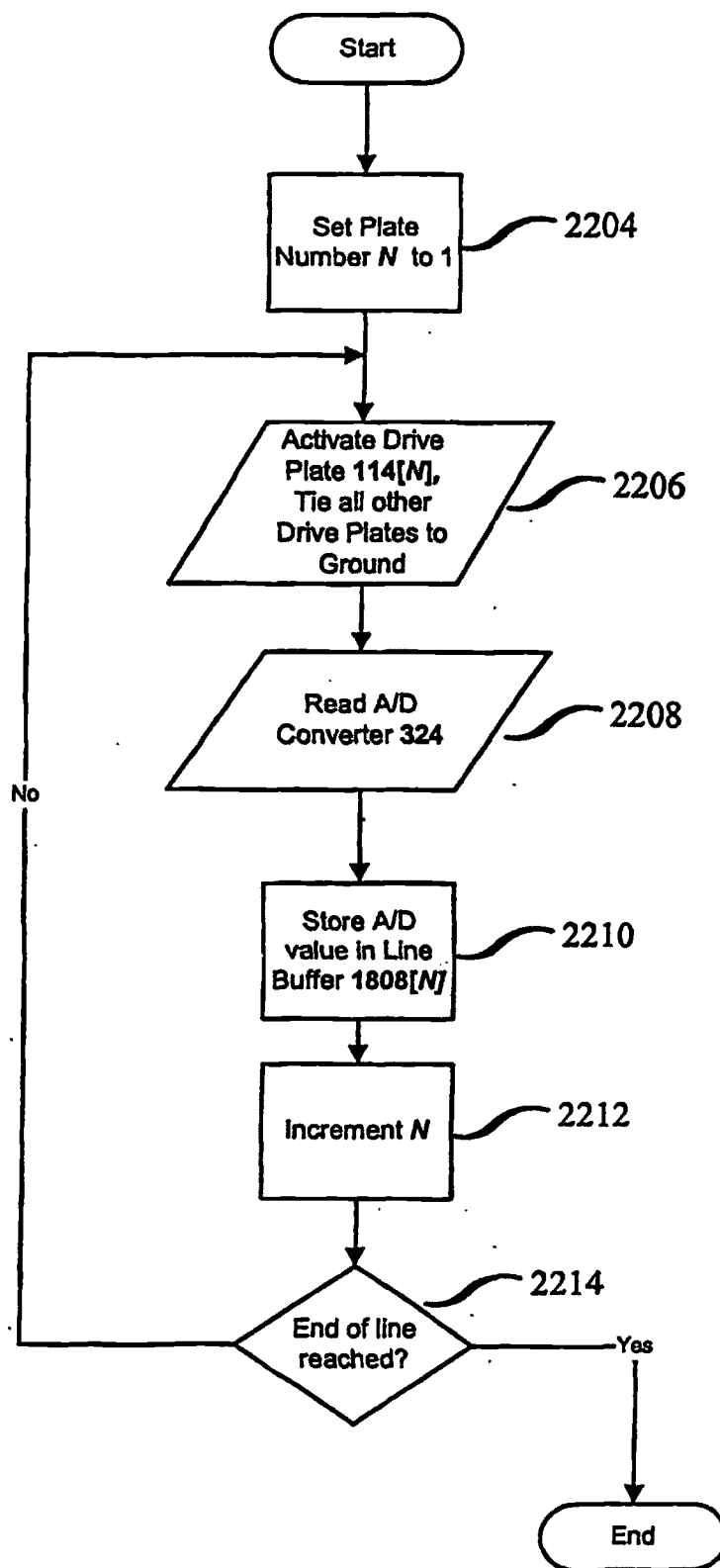
Figure 22

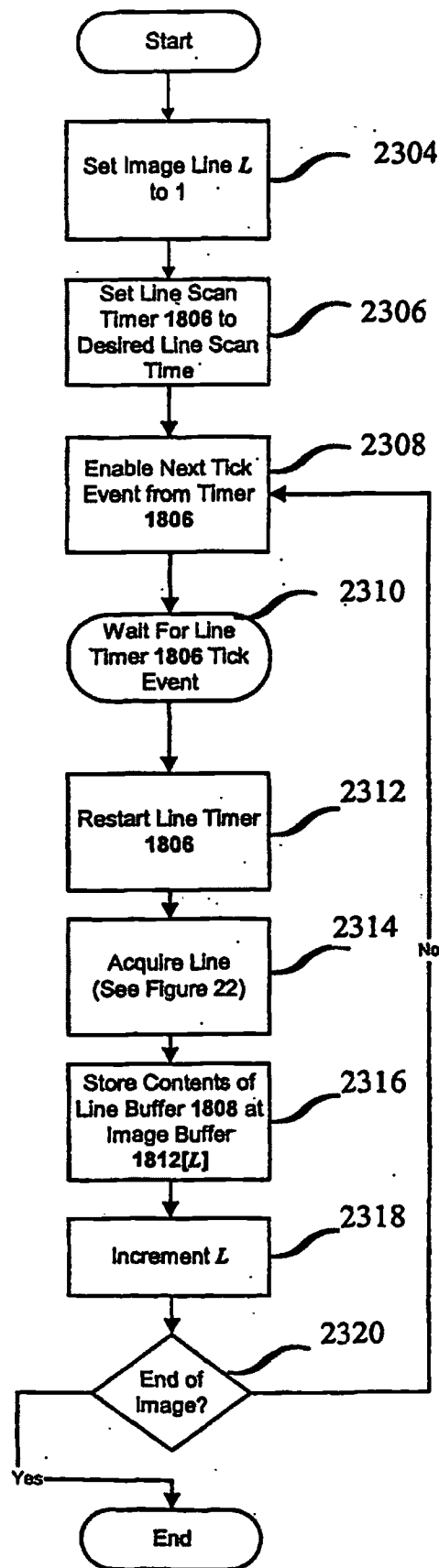
Figure 23

Figure 24